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on a

Proposed Draft Restoration Plan and Environmental Assessment for the Col-Tex State Superfund Site

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October 2002

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FINAL DRAFT
Habitat Enhancement and Restoration Plan
Compensatory Restoration
Col-Tex Site
Colorado City, Texas

Prepared for:

Texas Parks and Wildlife Department
Texas Commission on Environmental Quality
Texas General Land Office

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EXECUTIVE SUMMARY

The Texas Parks and Wildlife Department (TPWD), Texas Commission on Environmental Quality (TCEQ), and the Texas General Land Office (GLO) ("Trustees") have prepared this Draft Habitat Enhancement and Restoration Plan ("Plan") for the restoration of natural resources that were actually or potentially injured, lost or destroyed as a result of releases of hazardous substances or petroleum at the former Col-Tex Refinery site, located immediately west of Colorado City in Mitchell County, Texas. The former Col-Tex Refinery site lies north and south of U.S. Highway 80 (Business Interstate 20) and includes adjacent areas and portions of the Colorado River located north and east of the former refinery property. The refinery was in operation from 1924 to 1969. In 1994, it was listed as a Texas State Superfund Site and investigatory and remedial activities commenced under the supervision and guidance of the TCEQ.

The Potentially Responsible Parties (PRPs), ATOFINA Petrochemical, Inc. (formerly Fina Oil and Chemical Co.) and Chevron Environmental Management Co., together with the Trustees, collectively referred to as the "Parties" assessed and quantified potentially injured habitat using the Habitat Equivalency Analysis (HEA) approach. HEA was used to evaluate and quantify the injuries for each impacted habitat type. Specific input variables for each HEA model were based upon the data collected at the site. Using existing data, experience and best professional judgement, the Parties agreed on the size of the habitat areas potentially injured; the relative habitat services lost; and the duration of the losses. Compensatory restoration projects were proposed to restore the potentially injured natural resources to baseline conditions, and to compensate the environment and the public for the loss of ecological services.

Based on the results of the HEA calculation, a total of 1.5 acres of open water aquatic – pond construction, 2.4 acres of riverine aquatic/water quality improvement, 21 acres of riparian habitat construction, 25 acres of terrestrial habitat construction, and 35 acres of terrestrial habitat, placed in conservation in perpetuity, would compensate for losses of services provided by those habitats actually or potentially injured at the former Col-Tex Refinery site. A reasonable range of alternatives was evaluated by the Trustees prior to selecting the preferred alternative as the Proposed Action. The advantages and disadvantages of each alternative were evaluated to determine the preferred alternative. The key criteria applied during the evaluation of the alternatives included the ability to provide appropriate compensation, the likelihood of success, and the benefits to resources. In evaluating each alternative based on these criteria, the Parties were able to eliminate all but one alternative. The "best overall" candidate site where compensatory restoration can be implemented is a property located just west of Colorado City and adjacent to the former Refinery Site. This site includes the Colorado River riparian corridor and upland areas located between the river and Highway 80 (Refer to Figure 6.1). This site offers an opportunity to create a connected mosaic of habitats that are adjacent to the area where potential injuries from operation of the former Col-Tex Refinery occurred.

Six goals have been established for the resource enhancement and restoration activities along the Colorado River and at the upland site. These goals are:

- Improve local river water quality and riverine aquatic habitat in the project reach;
- Restore a native riparian corridor habitat along the Colorado River;
- Restore and enhance the native upland scrub/shrub vegetative community;
- Create a freshwater aquatic habitat system;
- Provide a sustained source of water for wildlife use; and
- Provide a limited-access public use and interpretive area for environmental education.

River Water Quality. The Colorado River water quality and aquatic habitat improvements will be accomplished through: reduction in local sediment supply to the river; creation of a canopy cover over the river through establishment of a native riparian vegetative corridor; providing a source of woody debris and leaf litter to the river for habitat diversity; and minimizing disruption to existing habitats. Erosion control measures will be installed on a large gully located on the north side of the river midway in the project reach.

Riparian Habitat. Restoration of the native riparian vegetation will provide benefits to the natural resources of the Colorado River through removal of exotic salt cedar trees and revegetation of the resulting cleared area with native woody tree, shrub, and herbaceous species. Priority activities for riparian enhancement include: salt cedar control; soil preparation through amendments; installation of a drip irrigation system for tree and shrub establishment; native revegetation; and fencing installation.

Upland Vegetative Community. Approximately 35 acres of upland habitat on the south side of the river is vegetated with native scrub/shrub species and mesquite and will be conserved in its current condition. In addition, approximately 25 acres of former agricultural fields located at the eastern end of the project site will be restored to an upland vegetative community, using native forb, grass, and shrub species. Of that 25 acres, approximately 7 acres will be planted in shrub and tree species. Activities included in the proposed scrub/shrub habitat restoration project include: surface grading and erosion control, undesirable species control, seedbed preparation, seeding, mulching, and transplanting.

Freshwater Aquatic Habitat. An existing stock pond is located on the south side of the Colorado River. A large drainageway bypasses the stock pond just east of its location. As proposed, a drainage swale will be constructed to connect this drainageway to the existing pond, thus increasing the amount of runoff that will contribute to the pond. In addition, the existing pond will be enhanced by regrading the base of the pond to increase its capacity to hold water. Erosion control measures will be used at the pond's perimeter to minimize soil erosion from the near banks. Revegetation of the ponds' perimeters will be accomplished through seeding, transplants and natural colonization.

Wildlife Water Source. A wildlife water catchment (guzzler) consisting of an apron for collecting precipitation, a tank to store collected rainfall, and a trough that provides access to the water by different-sized wildlife species will be installed in the eastern portion of the project site within the upland restoration area. The planting plan for this upland area will be designed to provide variability in food sources and adequate areas of cover adjacent to the guzzler for target species.

Public Use. At the PRP's option and with TDCJ approval, an interpretive trail and a scenic viewing area with signs is proposed on the south side of the Colorado River within the upland area. Public access to the interpretive trail would be controlled and scheduled by a local party to minimize negative impacts to the conservation area and wildlife that uses the habitats. Public access to the site would be limited at the scenic viewing area through fencing.

Monitoring. The habitat enhancement and restoration plan will be implemented starting in the fall of the first year following the execution of the settlement agreement and continue during the next two years. It is anticipated that construction of all habitat elements will be completed in the spring of the third year. Monitoring will begin after construction of each restoration plan element is complete. For the riparian area, monitoring will begin as each phase is completed.

The purpose of monitoring is to: obtain an objective assessment of project progress towards pre-determined project goals and performance standards; identify and correct problems through an adaptive management approach; and ensure that the PRPs meet their compensatory restoration obligations. Monitoring of the site will be a cooperative process. The PRP is responsible for implementing the monitoring plan. The Trustees will oversee monitoring efforts, review monitoring results and make decisions regarding corrective actions. Monitoring of the site will utilize qualitative methods; however, in the event that there is disagreement as to whether the performance criteria are being met by a particular portion of the restoration project or the project as a whole, a quantitative survey would be conducted.

Performance standards related to plant survival have been established for the riparian and upland components of the restoration project. Performance standards have also been established for the emergent vegetation surrounding the pond enhancement based on area of cover. Specific performance criteria have not been set for the erosion control structure, pond structure, or wildlife water catchment portions of the restoration. Parameters to measure development of the pond and erosion control measures will only be recorded for comparison purposes.

Each project component will undergo certification by the Trustees at the time of installation if installed to set specifications and upon completion of their respective monitoring period if performance standards are met. At that time, the property will continue to be held in a conservation easement in perpetuity.

1.0 INTRODUCTION

The Texas Parks and Wildlife Department (TPWD), Texas Commission on Environmental Quality (TCEQ), and the Texas General Land Office (GLO) ("Trustees") have prepared this Draft Habitat Enhancement and Restoration Plan ("Plan") for the restoration of natural resources that were potentially injured, lost or destroyed as a result of releases of hazardous substances or petroleum at the former Col-Tex Refinery site, located near Colorado City in Mitchell County, Texas. The Trustees have prepared this Plan pursuant to federal law in furtherance of the Trustees' responsibilities to restore, replace, rehabilitate or acquire the equivalent of injured natural resources. This Plan will become final upon the completion of any necessary changes made in response to public comments.

The National Contingency Plan (NCP), 40 CFR §300.615 (d)(2) provides the Trustees and a potentially responsible party ("PRP") the opportunity to reach negotiated agreements pertaining to potential natural resource damages associated with releases of hazardous substances or petroleum. At the Col-Tex Site, ATOFINA Petrochemical, Inc. (formerly Fina Oil and Chemical Company) and Chevron Environmental Management Co. (collectively referred to as "the Companies"), both PRPs, agreed to work cooperatively with the Trustees in this regard. The Trustees and the Companies (collectively referred to as "the Parties") entered into a Memorandum of Agreement ("MOA") on March 13, 1998. This MOA was developed in recognition of the Parties common interest to determine whether natural resources have been or are likely to have been adversely affected by the release of contaminants that resulted from the historical refinery operations. The MOA also serves as an acknowledgment of the Companies' willingness to provide funding to conduct expeditious restoration of potentially affected natural resources.

Pursuant to the terms of the MOA, the Parties have cooperatively conducted an assessment of potential natural resource injury and developed a restoration strategy to be jointly implemented by the Parties. The Parties have agreed to the extent and degree of potential injury to the natural resources for the purposes of furthering the cooperative restoration project. For the purposes of this Plan, the term "injury" refers to the injury agreed to by the Parties. This agreement of injury is not intended, nor will it be used by the Parties, as an admission of liability or factual allegations of any kind.

1.1 The Trustees' Responsibilities

The Trustees entered into the MOA in accordance with the legal authorities provided to each Trustee by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), Oil Pollution Act of 1990 (OPA), 33

U.S.C. §2701 et seq., the NCP, 40 CFR Part 300 and the Natural Resource Damages Assessment Regulations, 43 CFR Part 11.

1.2 Public Notification and Review of the Restoration Plan

The Trustees have provided the public with a notice of availability of this draft Plan. The Trustees placed notice in the Texas Register and the Colorado City Record. A copy of this document can also be accessed at on the following web site:
http://www.TCEQ.state.tx.us/permitting/remed/site/nrt/

1.3 Comments on the Draft Restoration Plan

This Plan is available for review for a thirty (30)-day period commencing from the time of publication in the Texas Register. Interested parties who wish to comment on the Plan must do so in writing by the end of the 30-day comment period. Whenever possible, comments should address specific pages in the Plan and be as specific as possible. Requests for copies of the Plan and comments on the Plan should be sent to the following address:

Texas Commission on Environmental Quality
ATTN: Charles Brigance
Natural Resource Trustee Program
P.O. Box 13087, MC - 142
Austin, Texas 78711-3087

Phone: (512) 239-2238
Fax: (512) 239-4814

The Trustees will consider and respond to all written comments on the Plan, either with actual revisions to the Plan or with an explanation, as appropriate.

2.0 SITE BACKGROUND

The former Col-Tex Refinery site is located immediately west of Colorado City in Mitchell County, Texas and north and south of U.S. Highway 80 (Business Interstate 20). The site included adjacent areas and portions of the Colorado River located north and east of the former refinery property (Figure 2.1). The refinery was in operation from 1924 to 1969. In 1994, it was listed as a Texas State Superfund Site and investigatory and remedial activities commenced under the supervision and guidance of the TCEQ. A Biological Inventory and Evaluation ("BIE") and a Tier II Ecological Risk Assessment ("EcoRA") supported these investigations.

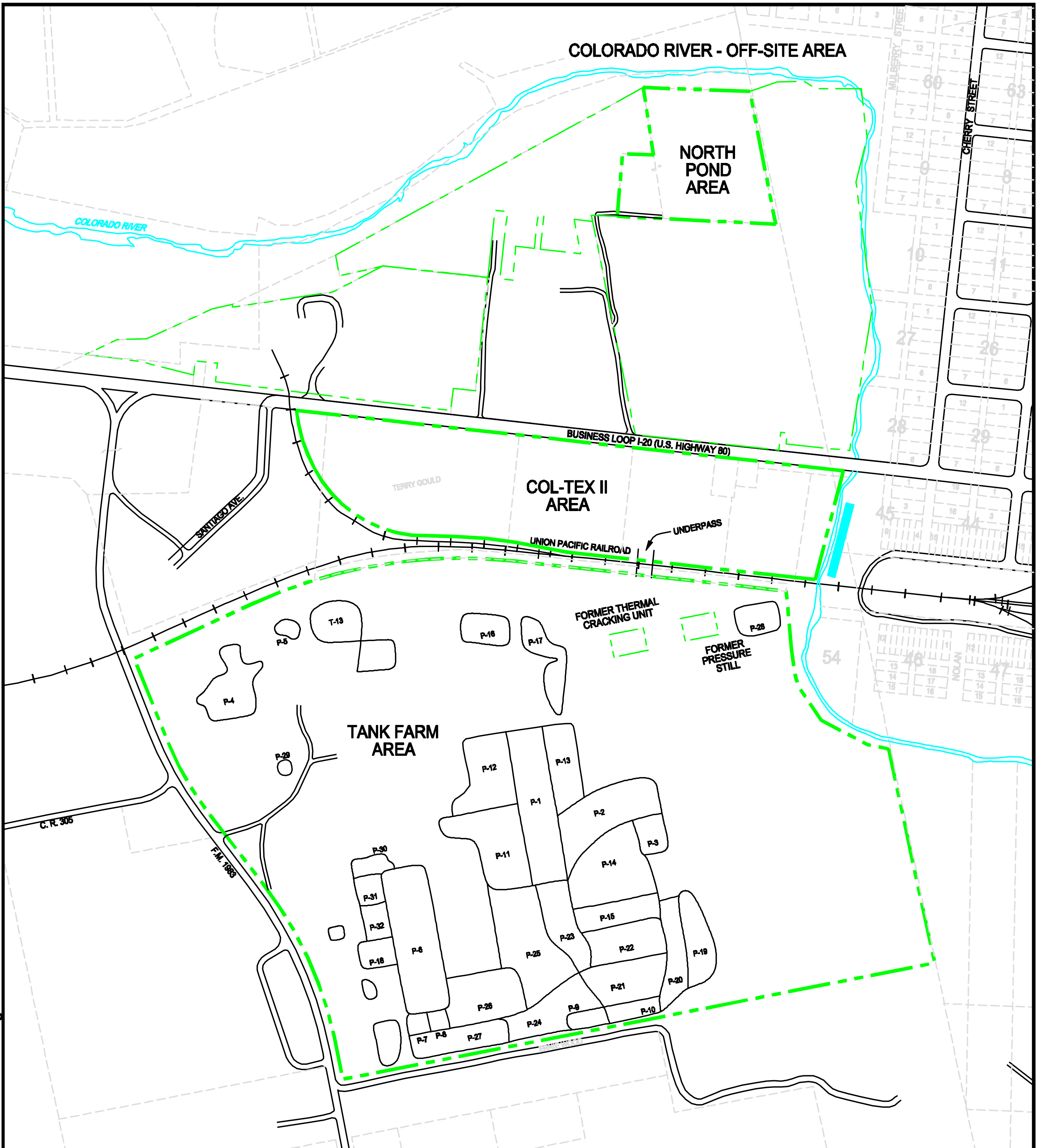
The cooperative assessment focused on the following areas that comprised the former Col-Tex Refinery site (Figure 2.1).

ON-SITE
- Tank Farm
- North Pond
- Col-Tex II Refinery

OFF-SITE
- Colorado River and adjacent riparian habitat

2.1 Tank Farm

The Tank Farm is a 158-acre parcel located primarily above a north- and east-facing bluff west of the Colorado River. A portion of the Tank Farm site is located below the bluff (to the northeast) and adjacent to the Colorado River. The Tank Farm site formerly contained 27 aboveground storage tanks and 29 unlined surface impoundments used to contain asphalt products. All structures and most of the impoundment dikes have been removed. Seven (7) of the surface impoundments (approximately 4.5 acres) were fitted with wildlife exclusion netting in the early 1990s to isolate the liquid or viscous asphalt/tar from avian and mammalian wildlife. The remaining surface impoundments (approximately 29.3 acres) were not fitted with wildlife exclusion netting since they contained a more consolidated surface layer and presented less risk of being mistaken for surface water. Eleven (11) of the impoundments were removed in January-April 1999 and the material was recycled into asphalt products. The remaining impoundments, requiring remediation, with the exception of one to be used as on-site surface water management will be removed in the next two years and recycled into asphalt products.



LEGEND:

- FORMER COL-TEX SITE, ONSITE AREAS

0 600
FEET

ENTRIX

Figure 2.1
Location Map
Former Col-Tex Site
Colorado City, Texas

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The Tank Farm site is primarily characterized by scrub/shrub vegetation, rock outcrops and disturbed ground associated with the refinery footprint remedial activities and removal of the surface impoundments. Groundwater seeps occur near the top of the bluff in several areas. Petroleum hydrocarbon staining from the seeps that occur between the top and the mid-point of the bluff are also visible. The seep water intermittently flows down the bluff face, into the alluvium below the bluff.

2.2 North Pond

The former North Pond asphalt impoundment covers an area of approximately 1.1 acres. The area surrounding the North Pond comprises approximately 7.5 acres of a relatively flat terrace that lies within a northward meander bend of the Colorado River. The North Pond area is bordered by the Colorado River channel and associated riparian vegetation on the north side and open pasture land to the east and west. Plowed cropland lies immediately to the south of the former North Pond. The vegetation in the North Pond area has been grazed by horses and cattle and there are very few trees on the parcel. The impoundment was fitted with wildlife exclusion netting in the early 1990s. The impoundment was removed in November-December 1998. Surface debris and refinery-related asphalt was also removed from the North Pond area in 2000 and early 2001.

2.3 Col-Tex II

The Col-Tex II area is the former location of the main refinery process area. It is approximately 18 acres and lies immediately south of Business I-20. The refinery occupied the area immediately below the bluff and north of the existing railroad tracks. The vegetative community has been disturbed over the entire area occupied by the refinery footprint and is dominated by grasses and annuals with some invading and colonizing herbaceous species.

Three (3) asphalt impoundments, covering an area of approximately 1.6 acres, were located in the Col-Tex II area and were fitted with wildlife exclusion netting in the early 1990s. These impoundments were removed in February-April 1998. Surface debris and refinery-related asphalt was also removed from the Col-Tex II area in 2000 and early 2001.

2.4 Colorado River and Adjacent Riparian Habitat

The Colorado River adjoins the former Col-Tex Refinery site, forming the northern and eastern boundary of the North Pond area and the eastern boundary of the Col-Tex II site. The river exits the property just east of the Tank Farm. North of the river lies the Wallace and Ware Units of the Texas Department of Criminal Justice ("TDCJ"). Riparian vegetation along the Colorado River is dominated by salt cedar (*Tamarisk gallica*) trees. Emergent vegetation along the river includes sedges, bulrushes, saltgrass, and cattails.

Two groundwater seeps with elevated concentrations of hydrocarbons are located along the Colorado River adjacent to the former Col-Tex Refinery site. Both seeps are being treated, under the direction of the TCEQ, with an abatement system to remove hydrocarbons from the groundwater.

3.0 DESCRIPTION OF HABITATS

Within the former Col-Tex Refinery site and adjacent off-site areas there are four major types of habitats, including:

- Open Water Aquatic
- Riverine Aquatic
- Riparian
- Terrestrial

The following is a description of each habitat type and the impacted areas.

3.1 Open Water Aquatic

Potential injuries associated with the surface impoundments at the former Col-Tex refinery site involve the loss of avian and mammalian wildlife that may have mistaken the asphalt and or oily/oily-water surfaces of the impoundments for an open water habitat and attempted to land on or wade into the water. Birds and mammals may have used these impoundments instead of a more suitable open water habitat.

Surface impoundments were located in the Tank Farm, North Pond, and Col-Tex II areas of the former Refinery Site. Some of these impoundments were fitted with wildlife exclusion netting in the early 1990s to minimize exposure to wildlife, as described above. In the Tank Farm area, there were approximately 8.2 acres of open water that resulted in potential injury to wildlife and a loss of aquatic habitat services. The remaining surface impoundments in the Tank Farm area were treated as a potential loss of terrestrial habitat, as described below. The North Pond and Col-Tex II area had asphalt impoundments that covered a total of 2.7 acres. The approximate area of open water that may have resulted in a loss of aquatic habitat at the former Refinery site is 9.3 acres.

3.2 Riverine Aquatic

The Colorado River is a natural river channel that flows adjacent to the former Col-Tex Refinery site and downstream through Colorado City, Texas. The river is naturally confined by sandstone outcrops of the Trujillo Formation resulting in right angle bends apparent in plan form.

The Upper Colorado River, located upstream of Spence Reservoir, including the reach adjacent to the site ("subject reach"), has elevated levels of salinity that are unrelated to the former Col-Tex Refinery site. Elevated salinity levels in the upper Colorado River is the greatest water quality concern in the river, according to the 1996 Regional Assessment of Water Quality – Colorado River Basin (Texas Clean Rivers Program, 1996). Since 1952, average discharge in the subject reach has been reduced by approximately 55% by an instream dam (Lake J.B. Thomas) located approximately 30 miles upstream (USGS, 1999). The effects of decreased flows, in combination with high inputs of sediment from regional agricultural lands have greatly influenced the morphology of the river and the availability of fisheries habitat. Historically, the subject reach was characterized by a meandering river with active side channel bars and pool-run sequences. As flows were reduced, the channel narrowed and salt cedar colonized the bars. Results from the BIE study show that the river upstream and downstream of the refinery site support benthic communities and fisheries common to rivers that are water quality limited.

Seeps that convey contaminated groundwater into the Colorado River potentially resulted in injury to riverine aquatic habitat over approximately 0.8 acres of open water. In addition, potential residual effects may have occurred over approximately 2.8 acres located downstream of the seeps.

3.3 Riparian

The riparian habitat along the Colorado River in the vicinity of the seeps may have been injured, as a result of elevated concentrations of hydrocarbons in the groundwater. These areas adjacent to the seeps total approximately 2.0 acres of riparian habitat.

Within the subject reach of the Colorado River, conditions such as lack of shading, poor controls on soil erosion, and increased soil and water salinity play a major role in the health of the riparian corridor. In addition, salt cedar trees dominate the riparian habitat. This non-native tree species increases the salinity of surface soil through its leaf litter and renders the soil inhospitable to native plant species. Salt cedar also crowds out native stands of riparian and wetland vegetation which would provide shade for the river channel while representing higher wildlife habitat values for foraging.

3.4 Terrestrial

Areas of potential concern in the Tank Farm, North Pond, and Col-Tex II areas were delineated during the Remedial Investigation, based on the presence of stained soil or soil analyses. These areas totaled approximately 26 acres of upland habitat. In addition, the development and operation of the surface impoundments in the Tank Farm area affected approximately 27.8 acres of upland habitat.

The affected upland habitat is considered to be terrestrial scrub-shrub habitat native to the region. This habitat supports native shrubs, forbs, and grasses.

4.0 INJURY DETERMINATION

The Parties assessed and quantified injured habitat using the Habitat Equivalency Analysis (HEA) approach. HEA mathematically determines the quantity of lost ecological services based on the quantification of potential natural resource injuries. The underlying assumption of HEA is that the environment and public may be compensated for ecological services lost in the past through the provision of additional ecological services of comparable type and quality in the future.

HEA was used to evaluate and quantify the injuries for each potentially impacted habitat type. Specific input variables for each HEA model were based upon the data collected at the site through the BIE study, and the site EcoRA. Using existing data, experience and best professional judgement, the Parties agreed on the size of the habitat areas potentially injured; the relative habitat services lost; and the duration of the losses.

A real discount rate of 3.0% was used for all calculations to place injuries in present value terms. In all analyses, the functional form of the service loss curve for the injured habitat was assumed to be linear.

Results of the habitat equivalency analyses for the individual habitats are summarized in Table 4.1 and provide an indication of the discounted service-acre-years for each particular habitat that was potentially lost as a result of the release of contaminants from historical refinery operations on the site. Based upon the results of the cooperative assessment, the Parties agreed that the lost discounted service-acre-years (LDSAYs) of the potential injuries to natural resources do not exceed those summarized in Table 4.1.

Table 4.1 – Summary of Habitat Equivalency Analysis Results

Habitat Type	Total Area Affected (ac)	Lost Discount Service Acre Years (LDSAYs)
Open Water Aquatic – Pond	9.3	276
Riverine Aquatic	3.6	60
Riparian	2.0	102
Terrestrial	53.8	1317

5.0 COMPENSATORY RESTORATION

The goal of restoration is to restore the potentially injured natural resources to baseline conditions, and to compensate the environment and the public for the loss of ecological services. The HEA does not differentiate between the baseline level of services provided by the habitat types at the former refinery site and at the restoration site, since in-kind restoration activities are provided as compensation.

When quantifying the benefits of creating habitat using HEA, information regarding the timing of construction, relative service flow, maturity curve, and expected lifetime of the restoration project is determined. Compensatory restoration for the former Col-Tex refinery site will begin within one year of the execution of the settlement agreement. Research indicates that constructed habitats do not generally provide the same level of ecological services as natural habitats. Therefore, the expected service flow of each restored habitat type was based on a percentage of the corresponding, and fully functional, natural habitat. The time required for each habitat type to reach the expected service flow was based on the best professional judgement of the Parties. In the analysis, the functional form of the maturity curve for created compensatory habitat was assumed to be linear. The constructed habitats were assumed to be held in perpetuity.

In order to maintain maximum flexibility in developing a restoration scheme that would adequately compensate for losses, the parties developed restoration credit HEA values for a number of different habitat conservation categories. HEA credits were developed for the construction and preservation of aquatic, riparian, and terrestrial habitats. Values were calculated for the preservation of existing functioning terrestrial habitat. HEA values were also developed for the enhancement of Colorado River water quality that might be expected from the construction of riparian habitat and the reduction of erosion of adjacent lands. In addition, given the difficulty in constructing successful aquatic restoration actions in the arid region in which the site is located, the parties developed trade-off values that would allow for the exchange of one habitat type for another. Relative habitat values were developed for the exchange between aquatic, riparian, and terrestrial habitats. Results of the HEA calculation of the compensatory restoration value of each potential action and trade-off values between habitat types are presented in Table 5.1.

Table 5.1 – Calculation of Total Services Provided by Restoration.

Habitat Conservation Action	Discount Service Acre Years (dSAYs – credit/acre)	Relative Habitat Value
Open Water Aquatic – Pond Construction	29.3	1.0
Riverine Water Quality Improvement	18.5	1.0
Riparian Habitat Construction	20.6	1.0
Terrestrial Habitat Construction Preservation	 21.4 16.4	0.4

In determining alternative restoration projects for consideration in the following Section 5.1 – Compensatory Restoration Alternatives, the parties acknowledged that a variable mix of habitats would be available for restoration. Therefore restoration credits were combined depending on the available habitats to create a total number of dSAYs that equal the total number of LDSAYs calculated in the injury assessment.

5.1 Compensatory Restoration Alternatives

Pursuant to DOI's NRDA Regulations (43 CFR Part 11), the Trustees must evaluate a reasonable range of alternatives before selecting the preferred alternative as the Proposed Action. The restoration alternatives, as evaluated by the Trustees, are as follows:

<u>**Alternative A:** Wetland and prairie grassland restoration at Lake Colorado City State Park</u> – Enhance native prairie grassland area and restore and enhance emergent wetland, shorebird, and avian habitat on Lake Colorado City. The State Park is located 11 miles southwest of the Col-Tex site.

<u>**Alternative B:** Prairie restoration and riparian and aquatic habitat enhancement at Maddin Native Prairie and Wildlife Preserve</u> – Restore native prairie habitat, create open water aquatic habitat, and enhance native riparian vegetation along the South Fork Champion Creek, a tributary to the Colorado River, located 10 miles south of the Col-Tex site.

Alternative C: Terrestrial and aquatic habitat enhancement at a Mitchell County Quarry and riparian restoration along the Colorado River – Enhance native upland grassland-scrub/shrub habitat and create open water aquatic habitat at a Mitchell County quarry located 10 miles east of the Col-Tex site; restore native riparian habitat and improve riverine water quality in the Colorado River on a reach located immediately west of Colorado City.

Alternative D: Terrestrial, aquatic, and riparian habitat enhancement and restoration on the Colorado River and adjacent uplands at TDCJ Prison property – Restore native riparian habitat and improve riverine water quality in the Colorado River, enhance and restore upland scrub-shrub habitat and create open water aquatic habitat and a wildlife water catchment on adjacent uplands immediately north and west of the Col-Tex site.

The primary goal of the proposed project is to restore and/or enhance native riparian habitat, upland terrestrial habitat, and open water aquatic habitat within the Colorado River watershed. A key objective in planning the enhancement and restoration project was to choose a restoration site that would create and conserve an integrated wildlife area such that all habitat elements were physically connected. The Parties first evaluated the potential projects based on the following factors to determine if each project would be included as a viable alternative:

- Nexus to the injury (i.e. in-kind vs. out-of-kind restoration)
- Proximity to the Col-Tex site
- Integration and geographic continuity of restored habitats
- Logistical issues

5.1.1 Alternative A: Wetland and prairie grassland restoration at Lake Colorado City State Park

The Lake Colorado City State Park is located approximately 11 miles southwest of Colorado City on the southwestern shore of Lake Colorado City. This lake was built on Morgan Creek, a tributary to the Colorado River and is managed for cooling water for an electric power plant and for water supply. The State Park is approximately 500 acres and is managed by the TPWD under a long-term lease. The park includes approximately 5 miles of shoreline on Lake Colorado City and approximately 150 acres that is managed as a native prairie grass preserve.

Habitat enhancement activities would include assisting the TPWD in restoring additional native prairie grassland, implementing soil erosion control measures along the lake shoreline, and enhancing or creating emergent freshwater wetlands along the lake shore.

Evaluation of Alternative A

- Nexus to the injury – Alternative A would result in enhancement of lake shore and native prairie habitats that differ from the potentially or actually injured habitats.
- Proximity to the Col-Tex site – The State Park is located within Mitchell County and within the Morgan Creek watershed. Morgan Creek enters the Colorado River downstream of the Col-Tex site. Of all the action alternatives, this site is located the farthest from the Col-Tex site.
- Integration and geographic continuity of restored habitats – The proposed enhancement projects would create a native prairie habitat located close to an enhanced shoreline habitat on a man made reservoir. The prairie is not contiguous with the lake and public use areas throughout the park would separate the restored habitats.
- Logistical issues – The land is leased by a public resource management agency, so long-term management of the project site may not be an issue. Public use of the park may result in a lower success rate for the restored habitats. Wetland construction at this site might not be compatible with Park management practices that attempt to maximize shoreline access for boaters and swimmers. The project would not have control over fluctuating lake levels and therefore the success of any emergent wetland restoration would likely be compromised.

5.1.2 Alternative B: Prairie restoration and riparian and aquatic habitat enhancement at Maddin Native Prairie and Wildlife Preserve

The Maddin Native Prairie and Wildlife Preserve is located approximately 10 miles southeast of Colorado City along the South Fork Champion Creek, a tributary to the Colorado River. The Native Prairie Association of Texas (NPAT) owns the 1,100-acre Preserve. Approximately 1.5 miles of the South Fork Champion Creek bisect the property at the north end. An old stock pond that is no longer functioning is located at the south end of the Preserve and is connected to the Creek's riparian area by a tree-lined corridor.

Habitat enhancement and restoration activities would include restoring native prairie grassland on approximately 106 acres of former cotton cropland, enhancing approximately 18 acres of riparian habitat through planting of native food source trees in existing corridor, creating a 4- to 6-acre open water aquatic habitat, and widening the corridor that links the pond to the riparian area and increasing the vegetative species diversity within this corridor.

Evaluation of Alternative B

- Nexus to the injury – Alternative B would result in creation of native prairie habitat that differs from the scrub/shrub habitat that is assumed to be injured at the Col-Tex site. The habitat services provided by grassland do not match those provided by a scrub/shrub habitat. The remainder of the enhancement projects would restore and enhance habitats comparable to those potentially injured.
- Proximity to the Col-Tex site – The Preserve is located approximately 10 miles from the Col-Tex site within Mitchell County and the Champion Creek watershed. Champion Creek enters the Colorado River downstream of the Col-Tex site.
- Integration and geographic continuity of restored habitats – Alternative B would result in a continuous link of restored habitats including the pond system, wildlife corridor, prairie and riparian area.
- Logistical issues – The Preserve is owned and managed by a non-profit organization whose goal is prairie grassland restoration in Texas (NPAT). This group would manage the property and resources. Based upon preliminary discussions with NPAT, goals of the organization may conflict with restoration needs.

5.1.3 Alternative C: Terrestrial and aquatic habitat enhancement at a Mitchell County quarry; riparian restoration on the Colorado River

Mitchell County has developed a quarry on a site that is approximately 240 acres located 10 miles east of Colorado City. The southern portion of the site is vegetated in mesquite, scrub/shrub species, and native grass. An old stock pond, functional windmill, and well are located at the southwest corner of the property.

Habitat enhancement opportunities at the site include planting native forbs and grasses within the upland area to provide additional diversity in the habitat. The stock pond would be enlarged and lined to hold more water for a longer period of time. Emergent and riparian vegetation would be planted at the shore to provide additional habitat for wildlife.

Also included in Alternative C would be enhancement and restoration of riparian habitat along the Colorado River. This portion of the project would be located just north of the Col-Tex site, within property owned by the TDCJ. Restoration would include removal of salt cedar, planting native riparian trees and shrubs, installation of fencing to exclude horses, and erosion control measures to decrease local inputs of sediment to the river.

Evaluation of Alternative C

- Nexus to the injury – Each of the habitats that would be enhanced through Alternative D match those potentially injured at the Col-Tex site.
- Proximity to the Col-Tex site – The upland and open water aquatic enhancement projects included in Alternative C would be located approximately 10 miles from the Col-Tex site. The riparian and riverine aquatic enhancement projects would be located adjacent to the Col-Tex site.
- Integration and geographic continuity of restored habitats – The upland habitat project and riverine habitat project would not be located on the same property. There would be no integration of the riparian corridor with the pond system or the upland area.
- Logistical issues – The operations and development of the quarry site may conflict with the functioning wildlife habitat that would result from this enhancement project. Long term management of the wildlife use areas would have to be taken on by some entity whose goals are consistent with the restoration project.

5.1.4 Alternative D: Terrestrial, aquatic, and riparian habitat enhancement and restoration on the Colorado River and adjacent uplands at TDCJ prison property

The TDCJ property is located to the north and west of the Col-Tex site, along the Colorado River. North of the river there are 19 acres of riparian habitat that have been cleared to the river's edge. South of the river there are an additional 15 acres of riparian habitat dominated by salt cedar. Of these 35 acres, 21 acres would be available for riparian habitat restoration. Also included in the TDCJ property are 35 acres of undeveloped land that is dominated by mesquite and scrub/shrub species and 25 acres of former rangeland, cropland, and industrial property located south of the river. Within the scrub/shrub upland area there is an old stock pond of approximately 0.5 acres in size during average rainfall years. This pond receives natural runoff and holds water during the wet season of most years.

Habitat enhancement opportunities at the TDCJ property site include: restoring 21 acres of riparian habitat through salt cedar control, revegetation with native riparian tree and shrub species, and installing fencing to exclude horses; installing erosion control measures and promoting tree growth to shade the river to improve Colorado River water quality along 2.4 acres of open water; enhancing and restoring 25 acres of upland scrub/shrub habitat; rehabilitating and enhancing an existing stock pond; and installing a wildlife water catchment device to create a permanent water supply for wildlife. The entire project property would be placed in a conservation easement.

Evaluation of Alternative D:

- Nexus to the injury – Alternative D would result in the enhancement of terrestrial and aquatic habitats that match those potentially injured at the Col-Tex site. The proposed restoration site is the same site used as the reference location for the BIE study. The bluff located at the Col-Tex site continues across Business I-20, and into the proposed restoration site, providing similar potential habitats at both sites.
- Proximity to the Col-Tex site – The proposed project site is contiguous with the Col-Tex site. A portion of the upland restoration project is located within the former North Pond area.
- Integration and geographic continuity of restored habitats – Each of the habitats included in Alternative D is geographically connected. The resulting habitats would be integrated along the entire length of the project reach of the Colorado River. Riparian restoration would be performed on both banks of the river with upland restoration along the entire southern bank of the river.
- Logistical issues – The property would be owned by the Texas Department of Criminal Justice, ATOFINA, and Lone Wolf. It may be possible to use prison labor to implement the restoration plan resulting in considerable cost savings.

5.2 Comparison of Alternatives

The Trustees evaluated the restoration alternatives based on, at a minimum, the following criteria:

1. Cost: The trustees consider the alternatives in terms of cost effectiveness and the relationship of costs to benefits. The Trustees will seek out the most benefit for the cost expended. If there are two or more preferred alternatives, then the Trustees select the most cost-effective alternative.

2. Provides Appropriate Compensation: This criterion is used to evaluate the effectiveness with which each alternative returns injured resources and services to baseline, thereby making the environment and public whole for direct losses.

3. Likelihood of Success: This criterion is used to evaluate whether each alternative is technically feasible. This is related to the issue of whether each alternative is likely or unlikely to succeed or achieve the goals.

4. Prevention of Collateral Injury: This criterion is used to evaluate each alternative with regard to its potential to cause additional injury or disturbance to natural resources.

5. Benefits to Resources. This criterion is used to evaluate whether each alternative would benefit only one, or more than one, resource or service. Trustees also evaluate the permanence and longevity of the benefits.

6. Public Health and Safety: This criterion is used to evaluate potential effects that proposed restoration action might have on human health, public safety and the environment, 43 CFR 11.82 (d) (8), 15 CFR 990.54(a)(6).

Comparison of each alternative relative to the Trustees' evaluation criteria, as described above, is provided in Table 5.2.1. The second table (Table 5.2.2) compares the effect each alternative would have on specific resource categories and to the public.

Table 5.2.1 – Comparison of Alternatives Based on Trustees' Criteria

Criteria	**Alternative A** State Park	**Alternative B** Maddin Preserve	**Alternative C** County Quarry	**Alternative D** TDCJ Property
1. Costs	Potential use of prison laborers may result in lower costs. No acquisition costs. Some increased transportation costs.	Potential use of prison laborers may result in lower costs. No acquisition costs. Some increased transportation costs.	Potential use of prison laborers may result in lower costs. Some increased transportation costs.	Lower costs due to availability of prison laborers to work on the site. Low transportation costs due to proximity to city.
2. Provides Appropriate Compensation	The services provided would differ from those potentially injured at the site.	Potential compensation for aquatic injuries. Terrestrial services provided would differ from those potentially injured at the site.	Compensation and return of in-kind services at off-site location is probable.	Compensation and return of on-site and in-kind services is likely.
3. Likelihood of success	Low potential success due to high public use in the park and fluctuations in lake levels.	Moderate potential success due to potential differing restoration goals of the land owner.	Moderate potential success due to quarry operations and development.	High potential for success.
4. Prevents Collateral Injury	Some potential for minor collateral injury from implementation.	Some potential for minor collateral injury from implementation.	Some potential for minor collateral injury from implementation.	Some potential for minor collateral injury from implementation.
5. Benefits to Resources	Benefits aquatic biota, birds and small mammals.	Benefits aquatic biota, birds and small and large mammals.	Benefits aquatic biota, birds and small mammals and large mammals. Fragmented nature of the project may convey less ecological benefit.	Benefits aquatic biota, birds and small and large mammals. Benefits Colorado River water quality by reducing erosion and sediment loading. Contiguous restoration for aquatic and terrestrial components.
6. Public Health and Safety	No effect on public health and safety.	No effect on public health and safety.	No effect on public health and safety.	No effect on public health and safety.

Table 5.2.2 – Comparison of Environmental Effects of Alternatives

Impacted Resource	**Alternative A** State Park	**Alternative B** Maddin Preserve	**Alternative E** County Quarry	**Alternative D** TDCJ Property
1. Vegetation	A different vegetative community will replace lost vegetation.	A different vegetative community will replace lost vegetation.	Lost vegetation will be replaced.	Lost vegetation will be replaced. Greatest potential for contiguous restoration that matches the lost vegetative community.
2. Soils	No significant impact to soils. Vegetative cover may stabilize exposed soils in the upland area. Potential pubic use of the shoreline areas may preclude shore stabilization.	No significant impact to soils. Vegetation may stabilize areas of potential erosion of creek banks.	No significant impact to soils. Vegetation may stabilize areas of potential erosion.	Vegetative cover will stabilize exposed soils. Gully erosion control and vegetative cover along the banks will result in decreased sedimentation and salt pollution in the Colorado River project reach.
3. Wildlife and Fisheries	Invertebrates, fish, birds and small and large mammals will benefit.	Invertebrates, fish, birds and small and large mammals will benefit.	Invertebrates, fish, birds and small and large mammals will benefit.	Invertebrates, fish, birds and small and large mammals will benefit.
4. Water Resources	Long term benefits to surface water.	Long term benefits to surface water. Requires long term use of groundwater to support stock pond.	Long term benefits to surface water. Requires long term use of groundwater to support stock pond.	Long term benefits to surface water quality. Short term use of groundwater for irrigation. Construction of pond and water catchment device to provide more dependable source of aquatic habitat and high quality drinking water for wildlife.
5. Air Quality	No effect.	No effect.	No effect.	No effect.
6. Cultural Resources	No effect.	No effect.	No effect.	No effect.
7. Recreation	Benefit recreational use of the Park by providing area to observe wildlife.	Provides wildlife area for potential recreational use.	Provides wildlife area for potential recreational use.	Provides wildlife area for potential recreational use.
8. Economic Conditions	No significant effect.	No significant effect.	No significant effect.	No significant effect.

5.3 Selection of Preferred Alternative

Both the potential benefits and negative impacts of each alternative were evaluated to determine a preferred alternative. The following section describes the process used to eliminate alternatives based on a hierarchical evaluation of the criteria. The highest priority criteria for evaluation of alternatives are its ability to provide appropriate compensation, its likelihood of success, and its benefits to resources. In evaluating each alternative based on these criteria, the Parties were able to eliminate all but one alternative.

5.3.1 Appropriateness of Compensation

Services provided by restoration activities at Alternative A, the State Park and Alternative B, Maddin Preserve would differ from those potentially injured at the Col-Tex site. Specifically, both Alternative A and B would provide native prairie grassland as compensation for injuries to native scrub/shrub habitat. The diversity of habitat and complexity of services provided would be less than the injury. In addition, Alternative A would provide lake wetland habitat as compensation for potential injuries to riverine aquatic and riparian habitat.

While Alternative C would provide in-kind services for all habitat types, the location of the compensation would be far from the Col-Tex site and considered off-site. On the other hand, Alternative D would offer both on-site and in-kind compensation for all habitats potentially injured by the Col-Tex site.

5.3.2 Likelihood of Success

Restoration activities at the State Park, Alternative A, have a lower likelihood of success than the other alternatives due to high public use and fluctuations in lake levels which may preclude long-term health of wetland habitats. Conflicting land uses and land owner goals at the Maddin Preserve and the County Quarry may result in a moderate likelihood of success. Alternative D would have the highest likelihood of success.

5.3.3 Benefits to Resources

While each alternative would provide benefits to natural resources including aquatic biota, birds, and mammals, Alternative C may provide less ecological benefit because of the fragmented nature of the project – the terrestrial and riparian/riverine habitats would be located on separate parcels.

Additional benefits would be realized through Alternative D located at the TDCJ property since restoration activities would benefit the Colorado River at the location of the injury. Water quality improvements may result by decreasing sediment loading and creating native riparian habitat to shade the water surface.

5.3.4 Summary

Based on the appropriateness of compensation, both Alternative A and B was eliminated from consideration. In addition, Alternative A was eliminated based on the low potential for success of the restoration activities. Alternative C was dismissed since the fragmented nature of the restored habitats would provide less ecological benefit than the contiguous habitats restored through the other alternatives. Therefore, consideration of the criteria identified for the site selection and evaluation indicates that the "best overall" candidate site for compensatory restoration work is the TDCJ property including the Colorado River riparian corridor (Alternative D). The goal of this resource enhancement and restoration project is to create an integrated mosaic of habitats that compensates for the actual and potential injuries to natural resources at the Col-Tex site.

5.4 Scaling of Restoration Actions

HEA was used to determine the acreage of each habitat that would be created and conserved at the TDCJ property. Table 5.4.1 outlines the scope of restoration actions, based on the calculation of discount service acre years per acre generated through construction and preservation of habitats. Table 5.4.2 compares the total amount of credits (dSAYs) generated to the lost services (dSAYs) at the Col-Tex site. As shown in the table, the restoration actions result in a deficiency of credits for aquatic and terrestrial resources and excess riparian credits. Excess riparian credits were allocated to aquatic habitat lost services at a ratio of 1:1 and to terrestrial habitat lost services at a ratio of 2.5:1, using the relative value of habitats, summarized in Table 5.1. Using this allocation, the resulting balance of dSAYs for each habitat type is zero.

Based on the results of the HEA calculation, a total of 1.5 acres of open water aquatic – pond construction, 2.4 acres of riverine aquatic/water quality improvement, 21 acres of riparian habitat construction, 25 acres of terrestrial habitat construction, and 35 acres of functioning terrestrial habitat conservation would compensate for losses of services provided by those habitats actually or potentially injured at the former Col-Tex Refinery site.

Table 5.4.1 – Scaling of Restoration Actions.

Habitat Type	Scope of Action (acres)	Credits (dSAYs / acre)	Total Credits (dSAYs)
Aquatic Pond River Water Quality	 1.5 2.4	 29.3 18.5	89
Riparian	21	20.6	432
Terrestrial Construction Preservation	 25 35	 21.4 16.4	1109

Table 5.4.2 – Allocation of Restoration Credits.

Habitat Type	Total Credits (dSAYs)	Lost Service (dSAYs)	Total Credits minus Lost Services (dSAYs)	Credit Allocation	Restoration Balance
Aquatic Pond River Water Quality	89	(337)	(248)	248 Riparian	0
Riparian	432	(102)	330	(330) {248 to aquatic and 82 to terrestrial}	0
Terrestrial Construction Preservation	1109	(1317)	(208)	208 {82 Riparian x 2.5}	0

6.0 RESTORATION DETAILS

The first step in developing an enhancement plan is to establish a set of goals to identify the desired outcome of each element of the project. Objectives are defined for each goal that present measurable parameters that can be used to guide the monitoring plan, as outlined in Section 7.0 – Monitoring Plan. Six goals have been established for the resource enhancement and restoration activities along the Colorado River and at the TDCJ site. These goals are:

- Improve local river water quality and riverine aquatic habitat in the project reach;
- Restore a native riparian corridor habitat along the Colorado River;
- Restore and enhance the native upland scrub/shrub vegetative community;
- Enhance a freshwater aquatic habitat system;
- Provide a sustained source of water for wildlife use; and
- Provide a limited-access public use and interpretive area for environmental education.

For each of these goals, objectives that define necessary actions are established. The following five sections correspond to each of the stated goals. In each subsection the objectives are first defined, then background information about the site is provided, and lastly specific actions to achieve the set goals and complete the resource enhancement and restoration project are described. Figure 6.1 illustrates the entire restoration project, as proposed in this Habitat Enhancement and Restoration Plan.

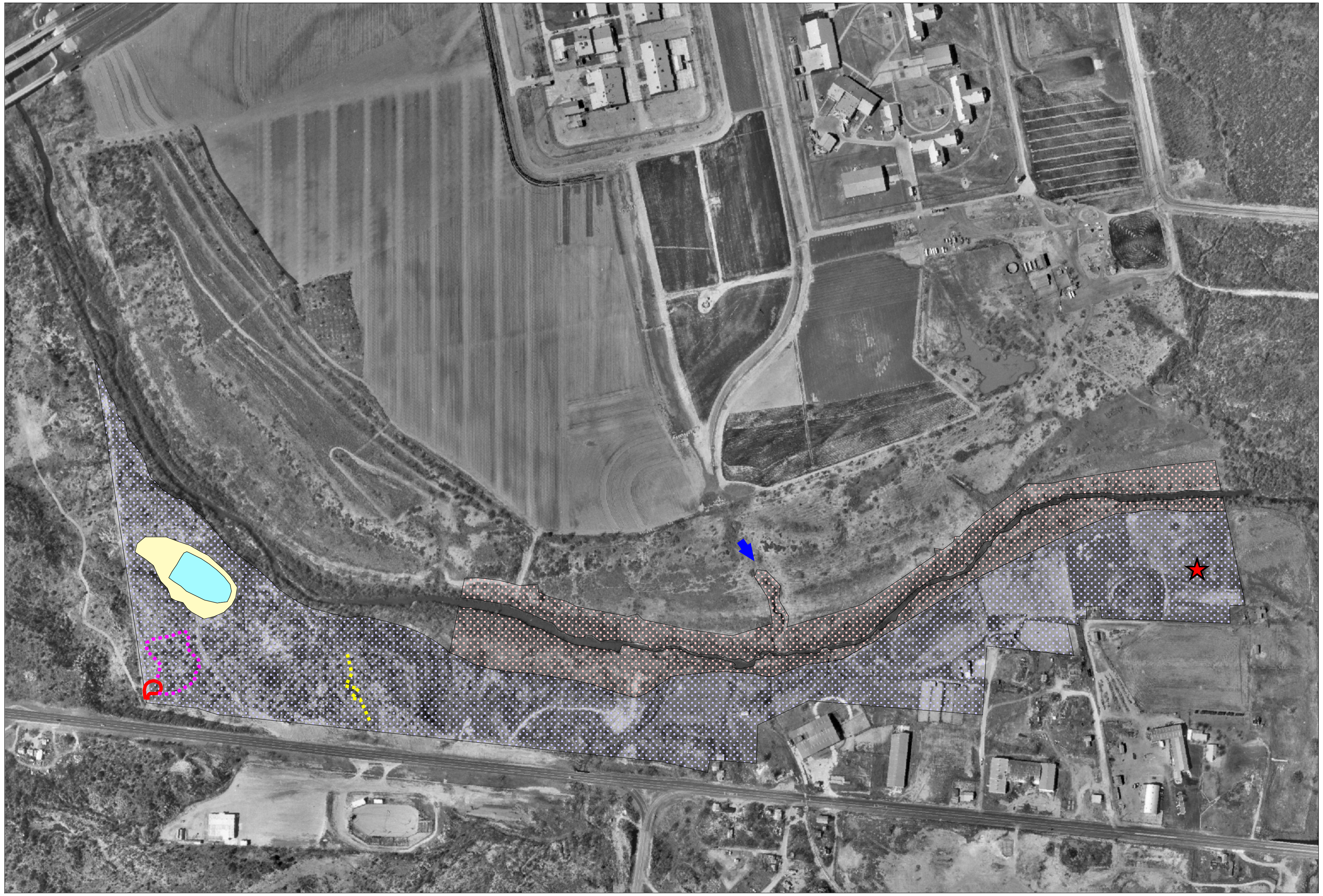
6.1 Improve Colorado River Water Quality and Aquatic Habitat

The goal as stated in Section 6.0 is to improve local river water quality and riverine aquatic habitat in the project reach. The objectives for this goal are:

- Decrease local sediment supply to the river;
- Create shading over the river through the establishment of a native riparian vegetative corridor;
- Provide source of woody debris and leaf litter to the river for habitat diversity; and
- Minimize disruption of existing habitats.

6.1.1 Background

This section describes the background hydrology, geomorphic character, sediment supply and deposition in the Colorado River at the project reach. Following the background section, there is a description of the existing conditions as they relate



Legend

- Riparian Restoration
- Uplands Enhancement and Conservation
- Pond System
- Erosion Control Structure
- Wildlife Watering Device
- "U" Drive for Vehicle Access
- Interpretive Trail
- Scenic Overlook Trail

N

500 0 500 Feet

ENTRIX

Figure 6.1

Project Location Map
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 2/19/01

to sediment supply and reduction. The final section provides a description of planned actions to meet the objective of decreasing local sediment supply to the river.

Hydrology. The Colorado River encompasses a drainage area of 3,966 mi^2 at the project reach. Streamflow has been regulated since 1953 by Lake J.B. Thomas located 31 miles upstream. At least 10% of the contributing drainage area is regulated by Lake J.B. Thomas where there are numerous diversions for municipal use and for oil field operations. The Colorado River Municipal Water District diverts low flow into the off-channel Barber Reservoir 3 miles upstream for brine disposal. Barber Reservoir began operating in 1973. A US Geological Survey gaging station (08121000) located in the project reach has been continuously operational since 1946 and briefly operated in 1924-1925.

Annual mean streamflow ranges from a low of 0.2 cfs (1998) to a high of 167 cfs (1948). Mean monthly streamflow for the period of record is shown in Table 6.1.1. Most runoff occurs in the month of May (134 cfs) and lowest runoff occurs in January (4.2 cfs).

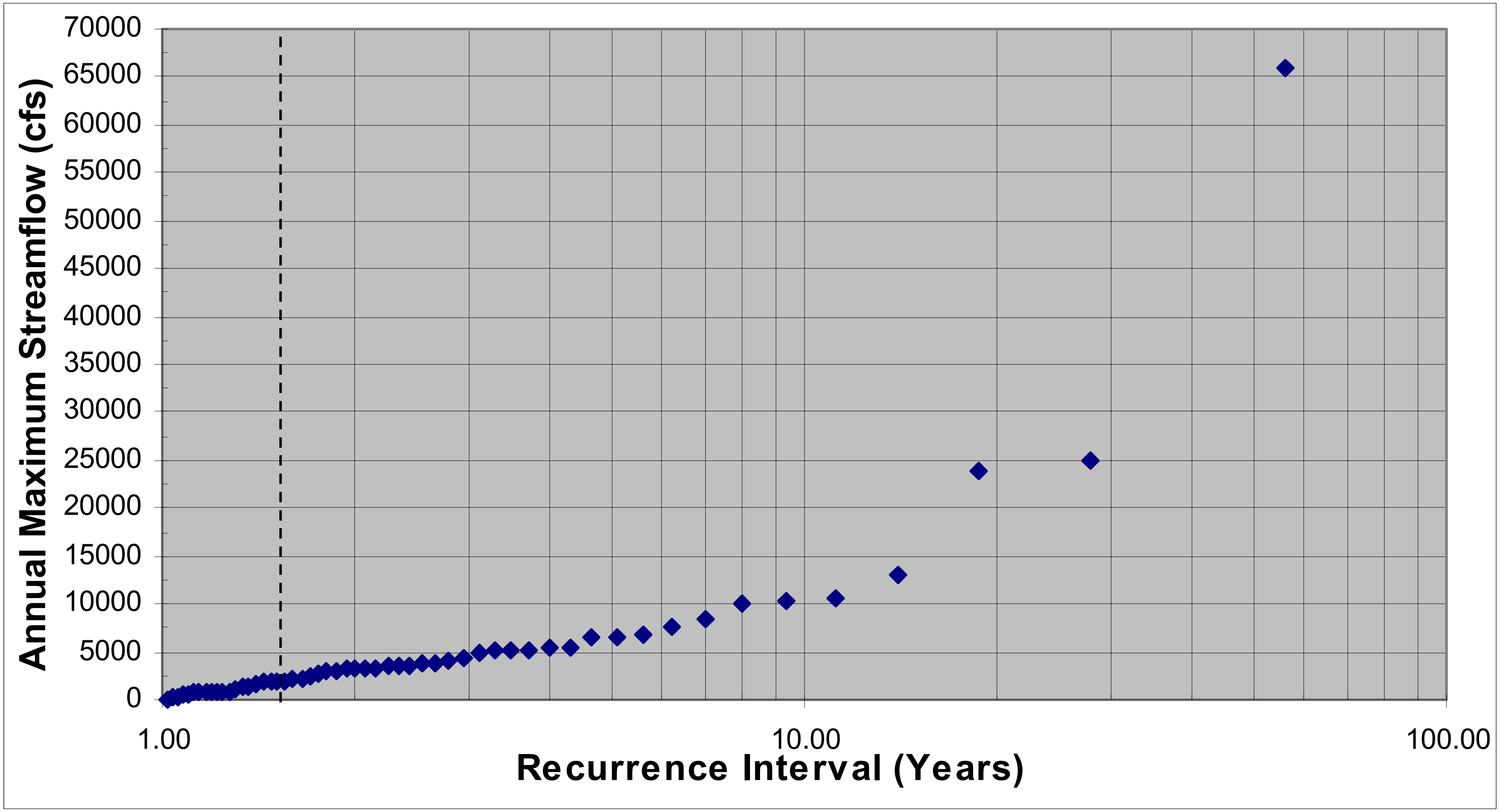
Table 6.1.1 – Mean monthly streamflow, Colorado River at Colorado City in cubic feet per second (cfs) (USGS Gage Station 08121000)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.2	10	6.8	39	134	83	50	53	69	40	7.5	6.6

Annual maximum streamflow (as average daily flow) has ranged from a low of 35 cfs (1970) to a high of 16,000 cfs (1948). Lake J.B. Thomas and other diversions have likely reduced the magnitude of peak runoff at Colorado City. However, the short nine-year streamflow gaging record prior to the construction of Lake J.B. Thomas (1924-1925 and 1946-1952), is not sufficient to determine the extent of influence the reservoir and diversions have had on high flow conditions. Nevertheless, it is notable that the two highest average daily flows for the period of record occurred prior to construction of the reservoir in 1948 (16,000 cfs) and 1947 (11,700) cfs. The third largest flood occurred in 1957 (9,560 cfs).

Figure 6.1.1 is a flood frequency graph of the streamflow (momentary peak discharge) associated with the highest flood for each year in the period of record since operation of Lake J.B. Thomas, 1953-1995. The graph plots the recurrence interval, which is a statistical calculation that indicates the average interval of time which a flood of a given magnitude will be equaled or exceeded. For example, a flood with a recurrence interval of 10 years (11,000 cfs in Figure

Figure 6.1.1 – Colorado River Flood Frequency Curve
USGS Gage Station 08121000 at Colorado City
Water Years 1953 - 1995



6.1.1) will be equaled or exceeded on average once every 10 years. This flood has a 10% chance of recurring in any one year.

The flow associated with the 1.5-year recurrence interval, 1,920 cfs in Figure 6.1.1 (dashed line indicates the 1.5-yr flow), is referred to as the bankfull discharge. The bankfull discharge typically occurs once every 2 out of 3 years and is the flow that completely fills the channel to the height of the adjacent floodplain. Bankfull discharge has special significance because it is the dominant flow responsible for maintaining the overall channel form. Higher flows which spill over-bank onto the flood plain may also influence the form of the channel, however they occur less frequently than the 1.5-year flood so that over the long-term, the bankfull discharge is most effective at doing work in the channel – that is moving sediment and maintaining the channel form.

Geomorphology. Aquatic habitat in streams is closely linked to channel forming processes. Habitat is created and maintained by the physical interaction of the hydraulic forces of flowing water against the bed and bank of the channel (Murphy and Meehan, 1991). Watershed conditions, including geologic setting, topography, valley gradient, sediment size and amount, presence and extent of riparian vegetation, and streamflow regime are important factors influencing channel form and processes. In turn, channel morphology affects the amount and distribution of pool, riffle, and run habitat utilized by fish.

A river channel can be characterized by a particular combination of channel morphologic characteristics that describe the shape, form, and pattern of the channel. Using these morphologic characteristics Rosgen (1996) developed a stream classification system which provides insights into channel processes and behavior.

Morphologic parameters, such as channel gradient, bankfull width and depth, entrenchment, sinuosity, and dominant particle size were measured and observed during field surveys conducted in November 1999. The longitudinal profile was measured from the I-20 Bridge to the downstream end of the project reach. Four (4) cross sections were surveyed to classify the reach. Measurements were done using a laser level. Table 6.1.2 shows the results of the measurements that define the morphologic characteristics of the project reach.

Table 6.1.2 – Morphologic Characteristics of the Project Reach

Parameters	XS @ Gage	XS 1	XS 2	XS 3
Width at bankfull (W_{bkf}) (ft)	159	68	43	122
Avg depth bankfull (d_{bkf}) (ft)	9.2	3.68	2.45	3.69
Floodprone width at 2x bankfull depth (ft)	330	220	200	>200
Width/Depth ratio	17.2	18.5	17.5	33.1
Entrenchment Ratio	2.07	3.24	4.65	1.6+
Sinuosity	1.11	1.11	1.11	1.11
Slope (ft/ft)	.0008	.0008	.0008	.0008
Channel material	Silt/clay	Silt/clay	Silt/clay	Silt/clay

Note: entrenchment ratio at the USGS cross-section was based on best visual estimates of the flood prone width. At cross-section 3, the flood prone width was not estimated. The entrenchment ratio, 1.6, is based on the channel cross-section survey area only, but the flood prone width is likely much greater than 200 ft and therefore the resulting entrenchment ratio would be a larger value (as indicated by the +).

The last 5 morphologic parameters in Table 6.1.2, width/depth ratio, entrenchment ratio, sinuosity, slope, and channel material, are the primary delineative criteria used by Rosgen to identify stream type. Using Rosgen classification system criteria, the project reach is most closely identified with a C6c-type channel. The C6-type channel is a slightly entrenched, meandering, low-gradient, riffle-pool channel that is dominated by silts/clay and has an adjoining floodplain. When channel gradients are less than .001, the stream type is identified as a C6c to indicate the very low gradients. High organic composition, including peat, is often associated with C6 channel types. A considerable amount of decomposed and decaying organic material was frequently observed in both pools and riffles along the project reach.

Rosgen (1996) notes that the presence and condition of riparian vegetation influence rates of lateral adjustment in C6 type channels. Well-developed riparian vegetation provides soil cohesiveness and reduces velocities near the streambank, resulting in slower rates of erosion. C6 channels lacking riparian vegetation are subject to greater near-bank velocities, higher shear stress, and greater rates of erosion. The C6 channel is highly susceptible to changes in both lateral and vertical stability (either aggradation or degradation of the streambed) due to direct channel disturbances or changes in the flow and sediment regime of the watershed (Rosgen, 1996). The natural sediment supply is usually moderate to high.

The Colorado River channel gradient (the upstream to downstream slope of the water surface) in the project reach is very low, approximately 0.00085 ft/ft (0.085%). Since gradient influences the kinetic energy available in flowing water, the river does not have a great capacity to transport sediments or erode the streambed and streambanks. The streambanks in the project reach are therefore relatively stable.

The width/depth ratio (ratio of bankfull surface width/mean bankfull depth), which characterizes the shape of the channel cross-section, was calculated for the project reach. The channel has a high width/depth ratio, which means that it is shallow and wide. These types of channels have a decreased capability to transport sediment.

The entrenchment ratio is an index computed by the width of the flood prone area at an elevation equivalent to twice the bankfull depth divided by the bankfull width. The entrenchment ratio of the project reach ranges from 2.07 to 4.65 and is considered to be slightly entrenched. Entrenchment refers to the degree to which the stream channel is vertically contained in its valley. Entrenchment ratios greater than 2.2 are typically associated with an adjoining, well-developed floodplain that is frequently over-banked during flood events. As shown in Table 6.1.2.

Sinuosity refers to the plan form pattern of the channel and is defined as the ratio of the stream length to valley length. Sinuosity for the project reach was determined by measuring the distance along the channel margin with a tape and then measuring the valley length from recent aerial photography. The resulting sinuosity is 1.11 for the project reach and is calculated by 7,771 ft (channel length) / 7,003 ft (valley length) = 1.11. The Colorado River in this location is moderately sinuous. Sandstone outcrops naturally confine the river resulting in right angle bends apparent in plan form.

Dominant particle size refers to the surface bed and bank material in the channel. The dominant particle size influences the sediment supply available for transport, the stability of the channel, and the relative resistance to bed and bank erosion. Generally, river channels that are predominantly composed of finer sediment sizes such as silts and clays, particularly if they are well-vegetated, are more stable than sand-dominated channels. Although there are various means of measuring dominant particle size, visual observations during the November 1999 field surveys was adequate for determining dominant particle size in the project reach. Silt and clay are the dominant particle size (<0.062 mm) and are very uniformly distributed throughout the channel. Except for one or two small bars, even fine gravels are almost non-existent in the project reach. Silty/clay materials are present to a depth of several feet in pools and are also the dominant particle size on riffles. Some sand-sized particles may also be present, although they are not a dominant particle size in the channel.

Sediment Supply and Deposition. It is evident from the presence of large bars and deep deposits of fine sediments in pools that there is a high sediment supply available to the project reach. Sources of sediment may be available from all parts of the Colorado River watershed. It is not known if the sediment load presently transported to the project reach represents an accelerated sediment supply. However, grazing and agriculture in both upland and riparian areas, and urban development are often recognized as land-use activities that can accelerate sediment delivery to streams.

Alteration of the hydrologic regime can also affect sediment supply and depositional patterns. A reduction in the magnitude and frequency of peak floods can eliminate over-bank flows, reduce sediment deposition on the floodplain, and increase the presence of fine sediments deposited in the channel. Reducing peak floods can also have the opposite effect on sediment supply by reducing the amount of bank and bed erosion. The complexity of interactions related to changes in the stream flow regime and changes in sediment supply related to land-use activities makes it extremely difficult to determine the nature, magnitude, and causes of adjustments occurring in the river channel without detailed investigations. An analysis of historical aerial photography for the project reach was performed to assist with determining if sediment loads over recent decades have been increasing, decreasing, or stable, and how the channel may be adjusting in response.

Time series aerial photography at an approximate scale of 1:2,400 was obtained for 1940, 1951, 1957, 1964, 1971, 1980, and 1996. It is immediately evident from the earliest 1940 photography that there are large depositional features in the form of point and side bars that are often more than two times the channel width. The size of the bars in the project reach are indicative of high sediment loads, but again, this is not necessarily an indicator of accelerated sediment production to the stream channel. C-type channels, as discussed above, are prone to transporting high sediment loads. It is possible that as of 1940 sediment loads to the river had already been altered from its natural condition, and has remained so into the present. Since there is no aerial photography available prior to 1940, the condition of the channel and sediment load prior to this time period could not be determined. Nevertheless, the size and configuration of the channel bars have remained essentially unchanged since 1940. The plan form (position and sinuosity) of the channel has also not changed, indicating that the stream is laterally very stable and that bank erosion rates have not appreciably changed during the past 60 years.

Field observations support the results of the aerial photographic assessment indicating that streambanks in the project reach are relatively stable. There was almost no evidence of mass wasting such as shallow landslides observed during the field surveys. There is active surface erosion evident along a large percentage of the project reach on both banks. However, some bank surface erosion is a natural process related to lateral migration of the channel which cuts the bank on the outside of meanders and deposits bars on the inside of the bend.

Given the stable channel plan form it is unlikely that sediment production and patterns of bar deposition in the channel are a result of local bank erosion. It is much more likely that sediment production is a watershed-wide issue and processes other than streambank erosion in the project reach are significant sources. Treating surface erosion on the streambanks would neither address the more significant sediment sources and would likely be inimical to natural lateral channel adjustments associated with a C-type channel.

The historical aerial photography does reveal a remarkable change in the low-flow channel width. This is due to colonization of the point and side bars by vegetation that has encroached on the channel. Between 1940 and 1971, the aerial photography shows long, wide and frequent bars with no vegetation. This indicates that scour of the bars by flood flows was regularly occurring in the past, preventing vegetation from establishing. Within one decade the aerial photography from 1980 shows that almost all of the bars along the project reach have stands of well-established vegetation dominated by salt cedar. By 1996 the vegetation has become dense, and has encroached on the low-flow channel area.

The change in low-flow channel width was quantified by measuring and comparing the 1964 and 1996 aerial photography. Eleven stations spaced approximately 200 ft apart were measured from bank-to-bank as defined by the vegetation along the channel margins. Low flow channel widths ranged between 40 ft to 134 ft in 1964. In 1996 the channel ranged from 13 ft to 50 ft wide, representing 38 to 89 percent reduction in the low-flow channel width, most of which has occurred between 1971 and 1980.

The presence of vegetation on the bars has a self-maintaining effect. During higher flows, the branches and leaves will reduce flood velocities, allowing more sediments to deposit on the bars causing aggradation, narrowing, and encroachment of the channel. The conditions that allowed vegetation to establish and encroach on the channel are not definitively known. It is possible that there has been a reduction in the frequency and magnitude of scouring floods due to reservoir development and diversions, as at least partially evidenced by the hydrologic record discussed above.

6.1.2 Existing Conditions

Actively eroding gullies have established on both sides of the Colorado River channel within the project area (Figure 6.1.2). The mechanism for initiation and growth of these gullies is probably a combination of concentrated runoff directed from the cotton fields, farm roads, storm drainage associated with the prison grounds, and removal of upland and riparian vegetation (associated with grazing, agricultural, and land use activities). Review of the historical photography indicates that many of these gullies existed prior to 1940 but have widened or lengthened during the last 60 years. Given the infrequent occurrence of high rainfall events in the semi-arid climate of the region, gully erosion and growth appears to occur on an episodic basis.

The gullies may be divided into two principal categories based on their location and ability to contribute additional sediment to the river channel. Non-contributing gullies include those located in upland areas that during most flow events deliver little, if any, sediment directly to the Colorado River. Contributing gullies include those that normally deliver sediment in surface flows directly to waters of the Colorado River.

<u>Non-Contributing Gullies</u>. There are numerous non-contributing gullies on the Colorado River banks within the project reach. These gullies drain the cotton fields, pastures, and a dirt farm road that skirts its perimeter. The gullies range from about 10 feet to 300 feet in length, are between 5 and 10 feet deep, and about 10 to 35 feet wide. In addition, there are numerous small- to medium-sized incipient gullies that have the potential to deliver sediment to the Colorado River in the future located on the north side of the Colorado River at the eastern end of the project reach. All of these gullies show evidence of active erosion and lack perennial vegetation, however they do not deliver sediment directly to the Colorado River. Eroded material is deposited on the margin of the floodplain. As long as perennial vegetation remains along the upper banks of the Colorado River channel, most sediment eroded from the cotton field, farm access road, and these four gullies will be deposited and remain in long-term storage within the upper portions of the flood plain.

<u>Contributing Gullies</u>. Contributing gullies are located on the north and south bank of the project reach. The gullies at the west end of the project reach originate off site on adjacent property. The drainage adjacent to the stock pond on the

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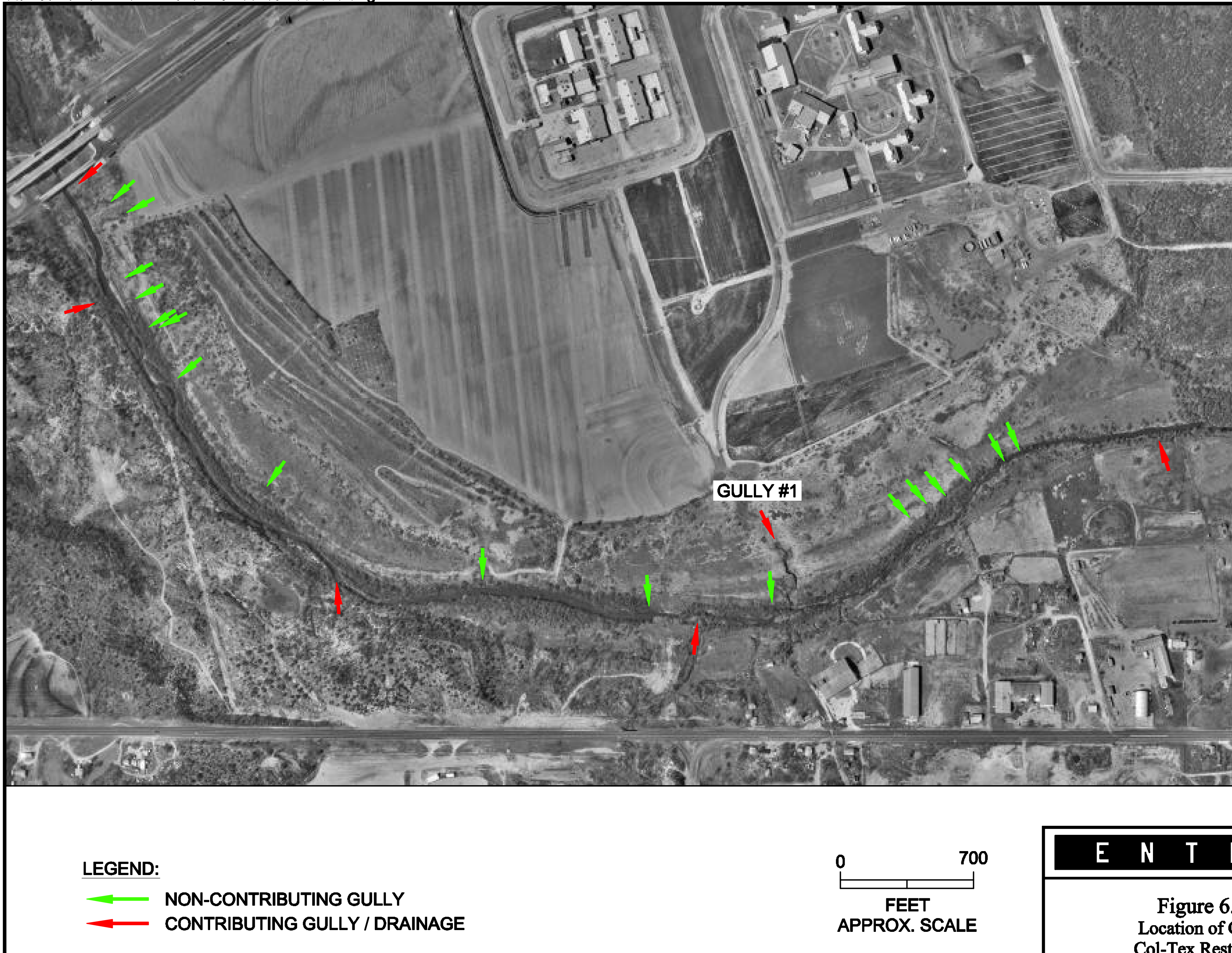


ENTRIX

Figure 6.1.2
Location of Gullies
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 02/00

southwest side of the project area will be addressed in the open water aquatic habitat enhancement project (see Section 6.4). The drainage that is located on the south bank about midway between the east and west project property boundaries is a manmade drainage to divert the flow of Rock Creek. This drainage is well vegetated and is not a significant source of sediment to the river. The contributing gully at the southeast project boundary is fairly small. Headward cutting of that gully will be alleviated through the upland scrub/shrub revegetation of the field, as described in Section 6.3.

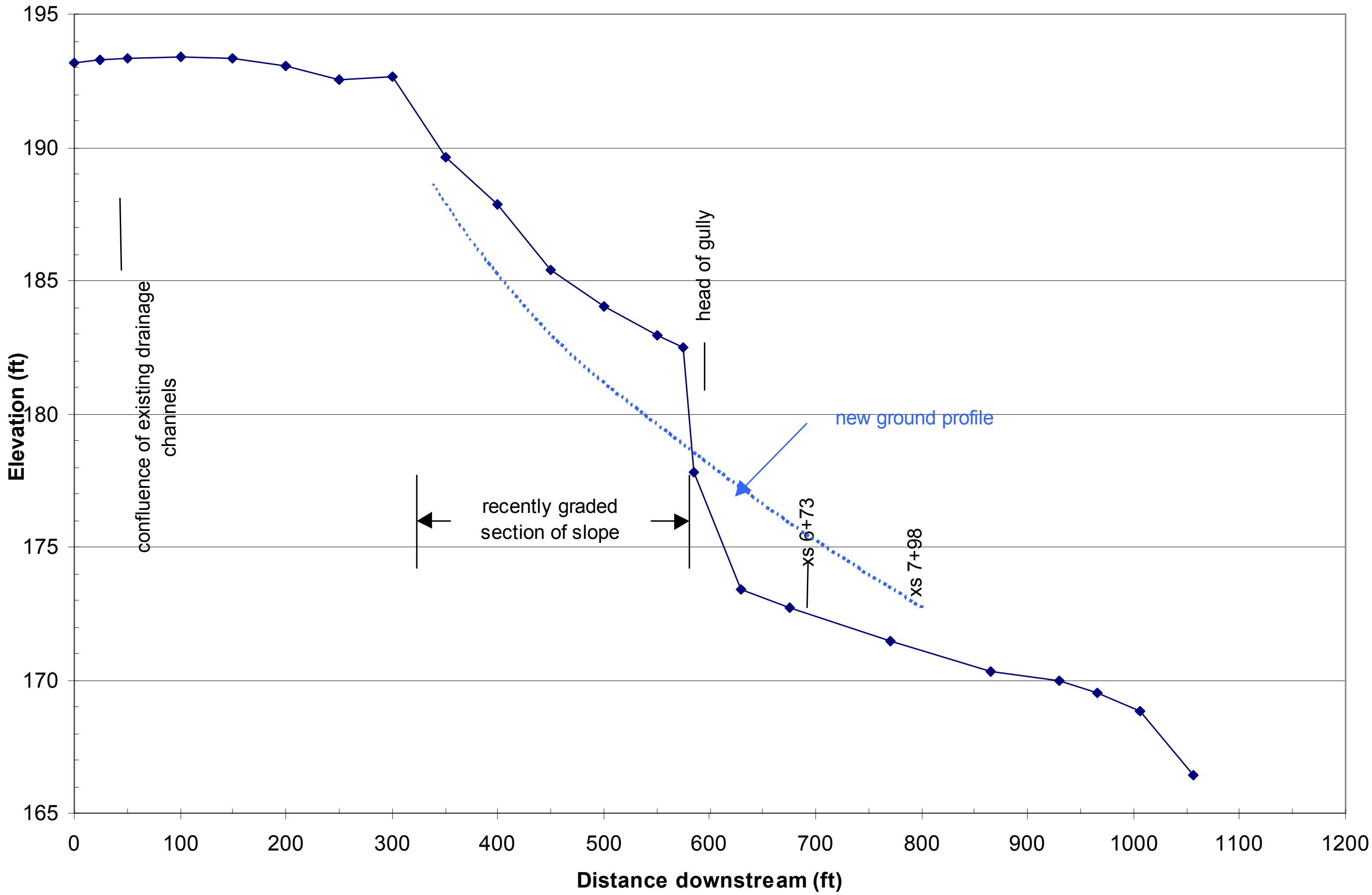
The largest contributing gully (Gully #1) is located on the north bank of the Colorado River about midway between the east and west project property boundaries (Figure 6.1.2). A major storm-drainage channel collects runoff from the prison grounds and routes it to gully #1. Loose rock check dams have been deployed at several locations in the storm-drainage channel that leads from the prison area presumably to control runoff velocities and prevent erosion of the channel. Gully #1 also drains a portion of the cotton and agricultural fields surrounding the prison facilities.

Gully # 1. Gully #1 is about 400 feet long, as shown on the longitudinal profile (Figure 6.1.3). For most of its length the gully banks are near-vertical, with slumping and mass failure evident along most of the gully length. The bottom of the gully is moderately stable with a relatively mild gradient of 1.5%. The mild gradient and growth of grasses along most of its length indicate that further incision (down-cutting) is unlikely to occur along the existing 400-foot gully length. An active head cut defines the upper end of the gully. This head cut is about 8 to 9 feet in height. It is actively eroding up-drainage, extending the gully's length.

Gully #1 also drains a portion of the surrounding agricultural terraces on the east and west sides. These terraces are also actively eroding, building side-branches to the main gully. Lateral bank erosion from terrace inflows has significantly widened the gully. Surface water runoff from the terrace outlets to the gully contribute to and complicate erosion and sedimentation problems.

Head cutting can be expected to continue to advance upstream, to the outlet of the prison storm-drainage ditch at the top of the terrace slope. When this has occurred, approximately 750 yds^3 of soil would be eroded and delivered to the Colorado River. If it is assumed that there will be only 1 foot of widening along the entire existing gully length on either bank, then approximately 355 yds^3 of additional sediment will be introduced. Total estimate of erosion from gully #1 due to head cutting and widening is 1,105 yds^3. This estimate is conservative and may well be much larger, since it does not include erosion associated with

Figure 6.1.3 – Gully #1 Longitudinal Profile
Measured: August 30, 2000



branching into the surrounding agricultural terraces, or account for a potentially greater amount of gully widening.

It should be noted that projected erosion and sediment delivery could be expected to take place over an extended time period (perhaps 50 to 100 years), since the rate of erosion is related to episodic, infrequent rainfall events. It is recommended that erosion and sedimentation control measures be designed and constructed to stabilize gully #1 and reduce sediment delivery to the Colorado River.

6.1.3 Planned Action

It is not likely that local bank erosion in the project reach is a significant source of accelerated sediment production to the Colorado River. The channel has maintained a stable lateral position for at least 60 years. Therefore, treatments to address local bank erosion would not significantly improve water quality or habitat conditions. The widespread nature of the deep, fine sediments covering the channel bed and high sediment load preclude most in-channel treatments which might be intended to alter stream morphology as a means of improving water quality or aquatic habitat. Structures placed in the channel to provide cover or complexity for aquatic habitat are likely to become buried and ineffective. Attempts to improve dissolved oxygen concentrations by increasing flow turbulence either through the introduction of gravels or other in-channel structures will also be prone to failure due to the high sediment loads and organic materials decomposing in the channel.

The best approach to improving water quality and habitat conditions is to work outside the active channel. The following actions will best improve conditions at the project reach scale:

- Reduce sediment delivery to the channel by allowing vegetation on the floodplain and upland areas to re-establish.
- Stabilize actively eroding gullies within the upper terraces that directly contribute sediment to the channel.
- Reduce sediment supply from adjacent property using Best Management Practices (BMP).

<u>Sediment Reduction.</u> During storm runoff events that generate overland flow in upland areas and peak floods that overbank the channel, sediment loads will be deposited on the flood plain where the flow velocity is slowed by the presence of vegetation. Vegetation acts as a “filter strip” reducing velocities, removing suspended sediments, and preventing direct delivery to the channel. Reestablishment of native riparian vegetation along the river will greatly reduce

sediment inputs to the channel. Recommendations for riparian enhancement and restoration are described below under Section 6.2.

Gully Stabilization. Gullies have established all along the project reach on both sides of the channel, as shown in Figure 6.1.2. The mechanism for initiation and growth of these gullies is likely a combination of concentrated runoff directed from the cotton fields, farm roads, storm drainage associated with the prison grounds, and removal of riparian vegetation (grazing and agricultural activities). Review of the historical photography indicates that many of these gullies existed prior to 1940. Field observations indicate that at least some of the gullies are actively eroding. Stabilizing gullies is a practical approach to reducing sediment input to the Colorado River. Specific recommendations for gully erosion control focus on Gully #1 and are as follows.

Flow conditions and characteristics are an important parameter for designing effective gully erosion control measures. Anticipated flows at Gully #1 were estimated using a 10-year, 1-hour and 100-year, 1-hour design storm events to assess the type of erosion control measures required.

Large scale maps of rainfall isohyetals in the US were used to determine the rainfall rates and runoff conditions applicable to Colorado City. The 10-year 1-hour rainfall event is approximately 2.6 inches, and the 100-year 1-hour rainfall is approximately 4.0 inches (Dunne and Leopold, 1978). In addition to these data, 75 years of precipitation records from the Colorado City rainfall gaging station were reviewed. The annual maximum 24-hour precipitation event for the period of record (1898-1995, discontinuous records) is plotted in Figure 6.1.4. The 20-year, 24-hour storm event has 5 inches of rainfall, and the 50-year, 24-hour storm event has 6.25 inches.

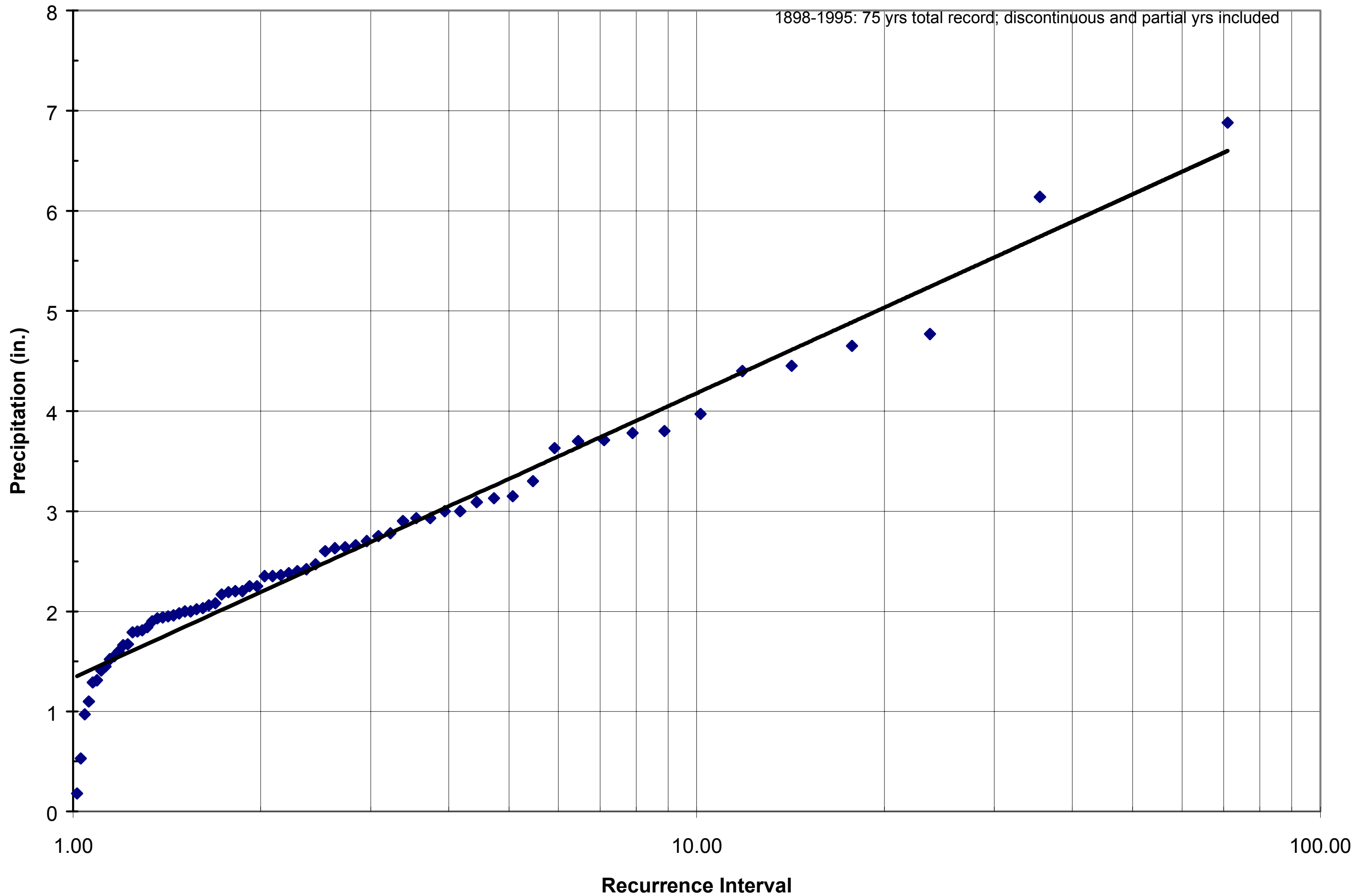
Using the rainfall intensities for the 10-year and 100-year, one-hour storm events, the rational method was used to calculate peak runoff. The rational formula for stormflow discharge is:

$Q_{pk} = CIA$

Where: Q_{pk} = peak rate of runoff
C = rational runoff coefficient
I = rainfall intensity
A = drainage area.

The drainage area associated with gully #1 is approximately 225 acres. Rainfall intensity for the 10-yr storm event is 2.6 inches/hr and for the 100-yr event is 4 inches/hr.

Figure 6.1.4 – Rainfall Frequency Curve for 24-hr Annual Maximum
Colorado City, Texas



The runoff coefficient C, is determined from tables of values developed by the American Society of Civil Engineers that reflect soil type, topography, surface roughness, vegetation, and land use. A weighted runoff coefficient for C of 0.51 was calculated using a weighted average of C-values distributed among the land-use types in the drainage area. The majority of land use (203 acres) in the gully #1 watershed is considered cultivated clay-loam soils, which has a runoff coefficient is 0.5.

The predicted peak runoff associated with a 10-year rainfall event is 298 cfs, and from a 100-year rainfall event is 459 cfs. The calculation of peak discharge for each storm event is:

10-year design storm $Q_{pk} = .51(2.6)(225) = 298$ cfs
100-year design storm $Q_{pk} = .51(.4.0)(225) = 459$ cfs

For erosion control design purposes, a peak runoff discharge of 380 cfs was used. This is half-way between the 10-year and 100-year rainfall events, and probably represents at least a 25-year to 50-year one-hour peak storm.

The peak runoff rates were then used to estimate expected flow velocities using a hydraulic model, winXSPRO, developed by the US Forest Service. The model considers the cross-sectional area and slope of the gully to calculate expected depths and velocities. Based on the model results, for the 380 cfs discharge the depth of flow in the existing gully will be 3.0 feet, with velocities of about 12.5 fps.

Gully #1 may be efficiently stabilized using a biotechnical approach by grading the gully headwall and side-walls to a more stable slope, and installing a geofabric liner which will be back-filled with soil and re-vegetated. The gully would be graded to appear and function as a wide, vegetated swale after restoration. Structural erosion control measures such as loose rock check dams and drop structures could also be effective but are not proposed. Such structural measures that create hard-points in the gully present a greater risk of failure than a biotechnical approach due to the potential for erosion of soils around the hardened structures.

A longitudinal profile of the existing gully is shown in Figure 6.1.3, beginning at the confluence of the two existing storm drainage channels that pass through the prison grounds and surrounding fields. Existing gradients range from approximately 6% to 1.5% in the lower portion of the gully, and there is nearly a 45% grade at the gully headwall. A new proposed ground-profile is shown in Figure 6.1.3. The new ground profile would be slightly concave in shape since this is the most stable form to which channels naturally tend. The average designed slope is 3.5%, similar to existing conditions, but the gradient of the steep headwall would be reduced, as shown.

The gully side walls will be graded back from vertical to about an 8:1 grade as shown in Figures 6.1.5 and 6.1.6. The bottom width of the gully will be widened to 25 ft, about the same as the current top width. The gully will be partially filled in order to establish a continuous 3.5% gradient. Filling from the downstream to upstream direction, the new drainage swale will start at grade about 100 ft upstream from the Colorado River (see Figure 6.1.3). The depth of fill will gradually increase in the upstream direction until the headwall of the gully is intercepted. Estimated fill depths of 3 ft and 4.5 ft for two cross-sections are shown in Figures 6.1.5 and 6.1.6, respectively. Fill material will be generated by grading back the vertical gully side walls. Upslope from the gully headwall, a small amount of cut will be required to maintain the 3.5% slope with a concave profile. Superficial solid wastes and debris will be removed from the site. Solid waste materials uncovered during excavation at the site will be buried within the project area or otherwise properly disposed of in accordance with TCEQ guidelines for solid waste management.

The fill material and graded gully walls will need to be compacted prior to installation of the geofabric material, and any vegetation, rocks, etc. must be cleared. The geofabric will be placed in the bottom of the designed swale starting about 250 ft upstream of the gully headwall, where the channel gradient begins to steepen (see Figure 6.1.3, Gully Longitudinal Profile). A total 650 ft length and 50 ft width of the drainage swale will be protected with the geofabric liner.

The proposed geofabric is a permanent turf reinforcement mat that consists of a dense web of polyproylene fibers positioned between two high strength nets, and mechanically bound by parallel stitching. The permanent turf reinforcement mat has several advantages over the use of other structural measures such as rip-rap and check dams to control gully erosion, including allowing infiltration of storm runoff and development of vegetation which will provide increased water quality benefits. In addition, there is comparatively less risk of erosion with the turf reinforcement mat than around hardened structures.

Runoff velocities, depth, width and shear stress were calculated using the winXSPRO hydraulic model for the restored drainage swale design. Average velocities associated with the design storm event (380 cfs) are expected to be 11.5 fps with flow depths of 1.0 ft, and top width of 40 ft, assuming a bare, earthen channel with no vegetation. Velocities will be slightly lower, with slightly greater depth and width when vegetation is established in the drainage swale. Based on these anticipated design storm runoff conditions, a suitable turf reinforcement mat can be selected.

Figure 6.1.5 – Gully #1 Cross-section at Station 7+98
Measured: August 30, 2000

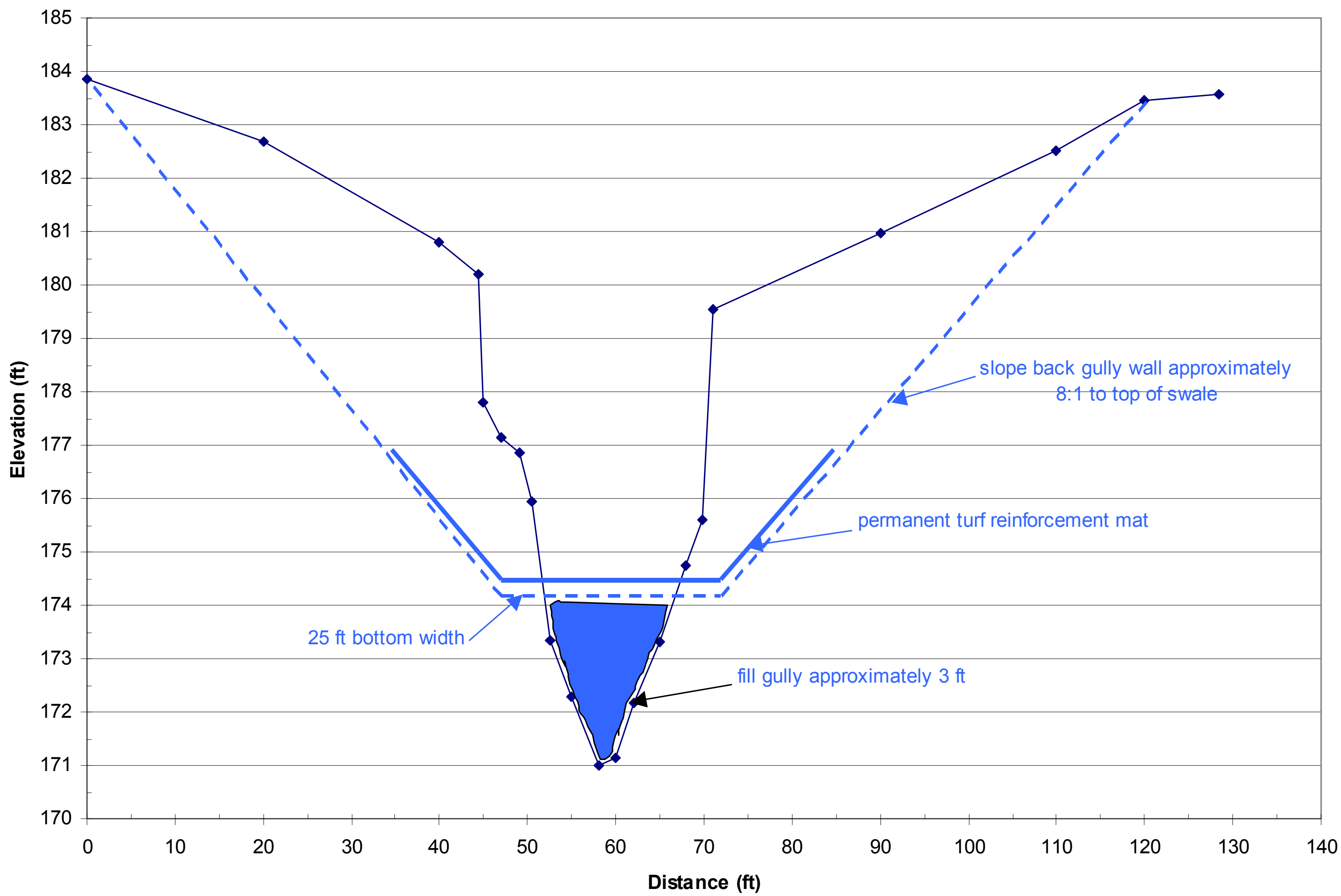
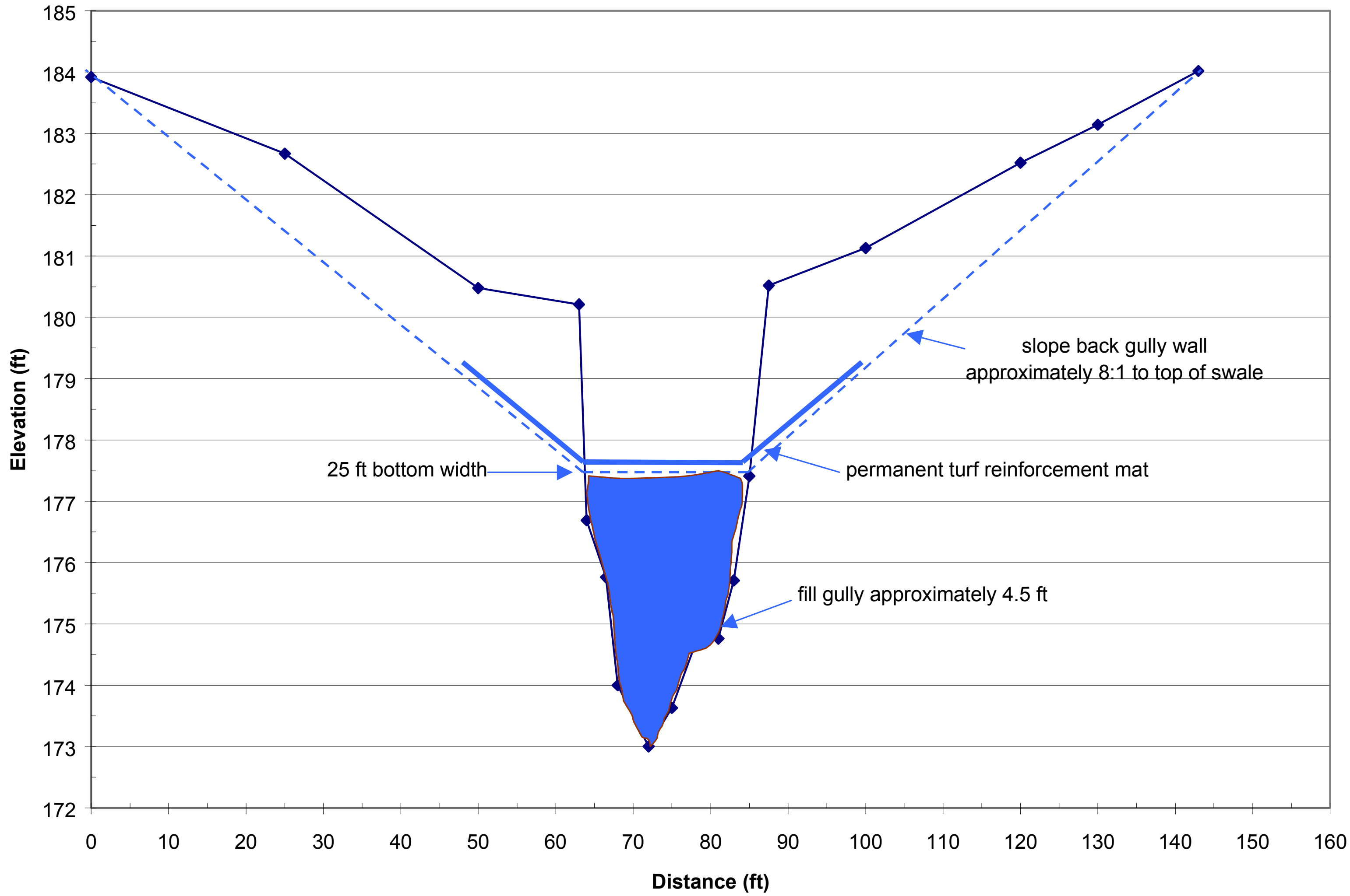


Figure 6.1.6 – Gully #1 Cross-section at Station 6+70
Measured: August 30, 2000



Establishment of vegetation in the drainage swale will be an important component of erosion control. The entire width of the drainage swale, approximately 140 ft, should be seeded with a seed mixture containing native, perennial, warm-season sod-forming and bunch type grasses. The seed mixture will consist of 50% buffalograss (*Buchloe dactyloides*), 25% sideoats grama, and 25% alkali sacaton. This vegetation mix has been recommended by the NRCS for erosion control in the region. This seed mix is placed on a prepared seedbed before the reinforced turf mat is installed. The vegetation grows through the porous spaces in the turf mat. Alternatively, toposoil can be placed on top of the turf mat after installation which is seeded with the erosion control mix so that grass roots will grow down into the geofabric liner.

In addition to the 50 foot-wide section to be protected at the bottom of the drainage swale with the reinforced turf mat, another 50 ft on either side of the swale should be protected with a standard net mat. The net mat holds the erosion control seed mix in place.

Figure 6.1.7 is a photograph of gully #1 with a view downslope. The approximate extent of the reinforced turf mat installation and erosion control seeding is shown.

Maintaining vegetation in the drainage swale, including the upper slopes will be necessary in order to slow the velocity of sheet runoff, reduce erosive forces, and to trap sediments. Field observations indicate that side branching of the main gully is occuring due to runoff from the agricultural fields bordering the swale. Establishing and maintaining complete vegetative cover over the swale will be an effective means to prevent continued side branching of the main gully.

<u>Best Management Practices.</u> In order to minimize land use and land management impacts, best management practices (BMP's) can be enacted to reduce erosion and to capture eroded sediments before they are delivered to the Colorado River. An important BMP to reduce sediment delivery to the river and to inhibit the growth of new gullies would be the establishment of a vegetative buffer strip. A vegetative buffer strip between the river and agricultural fields will act as a sediment filter that slows surface runoff, reduces sediment carrying capacity, protects the soil surface and allows sediments to deposit. Establishment of vegetative buffer strips is important in both upland and riparian areas, especially along the perimeter of the Colorado River floodplain. The establishment of a vegetative buffer along the north bank of the river is discussed in the riparian enhancement section (Section 6.2).

Other strategies to reduce soil erosion and capture sediment related to agricultural activities include contour plowing; use of cover crops, mulching or the spreading of crop residuals; and development of tail-water ponds. Contour plowing is

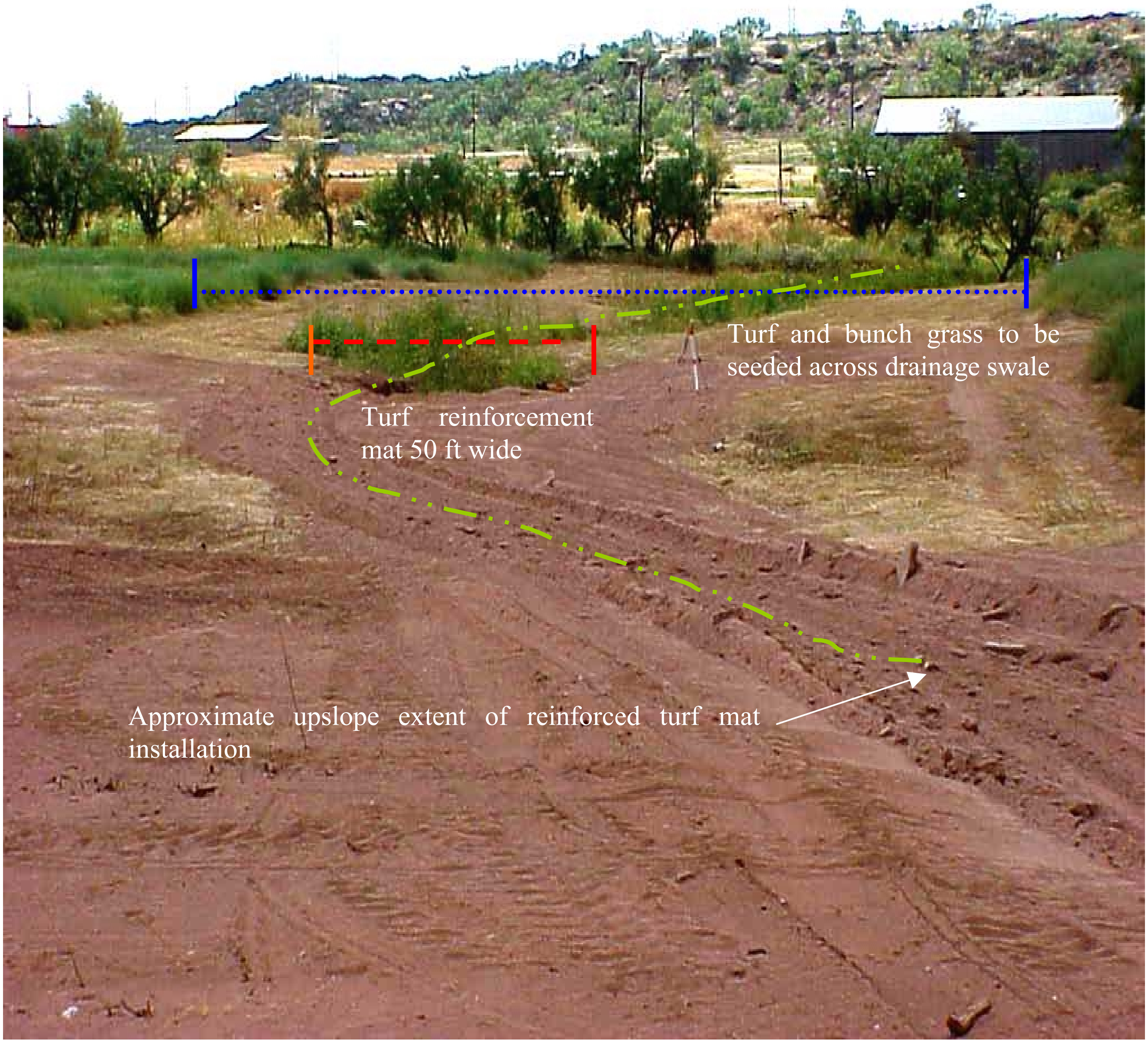


Figure 6.1.7 – Photograph of Gully #1, Looking Downslope.

Centerline of swale (green line), extent of reinforced turf mat installation (red line) and extent of erosion control seeding (blue line) across designed drainage swale is shown.

generally accepted as a BMP to control erosion and should be practiced whenever possible.

Cover crops can be planted on agricultural fields to provide temporary vegetative cover for the soil. Cover crops provide valuable erosion protection between crop rotations for soils that are mechanically disturbed by agricultural practices on a routine or periodic basis. In some cases it may be desirable to spread mulch or crop residuals on fields to aid in erosion and sedimentation control.

Tail-water ponds and similar structures can be used to capture sediment-laden water in runoff from agricultural fields prior to their release downstream. These ponds can consist of rock, earthen dams with lined spillways, concrete, or a variety of prefabricated materials. For the small gullies located at the downstream end of the project reach, water can be intercepted using drainage ditches placed on the contour at the margin of the field immediately above the headcuts. Runoff from these drainage ditches would be directed to a designated stable waterway.

The implementation of specific BMPs are not part of this restoration plan, however general recommendations will be made to the TDCJ to control erosion from land that lies adjacent to the project reach, on the north side of the river.

6.1.4 Timing of Activities

Erosion control measures will be implemented in the first year of restoration activities. Following the formulation of detailed design specifications, the gully erosion control structures will be installed in gully #1. It is anticipated that construction will begin in the late fall of the first year of restoration activities and the structures will be in place during the following wet season. Recommendations for BMPs will be made to the TDCJ in the form of a letter report and submitted to the agency by the end of the first year.

6.2 Restore Colorado River Native Riparian Habitat

The goal as stated in Section 6.0 is to restore the native habitat along the riparian corridor of the Colorado River. Objectives relating to this goal are:

- Revegetate the corridor using native riparian species that would increase local diversity;
- Control invasive salt cedar throughout the project reach;
- Increase shade along the river to improve water quality;
- Provide sources of woody debris and leaf litter to the river for habitat diversity; and

- Provide vegetation along the banks of the river to stabilize the streambanks and reduce soil erosion.

6.2.1 Background

Typically, riparian areas display a greater diversity of plant and wildlife species and range of vegetative structure than adjoining ecosystems. The quality of the riparian system within the subject reach of the Colorado River is significantly compromised. Salt cedar, an invasive, exotic species, is the dominant plant species along the banks of the Colorado River within the project area. Salt cedar increases the salinity of local surface soil through its leaf litter. This localized accumulation of salinity renders the soil inhospitable to native plant species intolerant of high levels of soil salinity. In effect, salt cedar crowds out native stands of riparian and wetland vegetation, which provide higher wildlife habitat values.

Restoration of the native riparian vegetation will provide benefits to the natural resources of the Colorado River in several ways. Removal of exotic salt cedar and revegetation of the resulting cleared area with native woody tree, shrub, and herbaceous species will increase the diversity of vegetation in the area as well as provide food source trees and cover for many avian and rodent species. Restoration of the woody river bank vegetation will also improve river habitat quality and benefit aquatic organisms. Over-hanging vegetation will provide cover for fish and amphibians, help maintain cooler water temperatures by shading the stream, and contribute leaves and woody debris which serve as important energy sources and habitat in aquatic ecosystems. Low-growing stream side vegetation will provide egg-laying and attachment sites for aquatic insects. The fibrous, below-ground roots of riparian vegetation will help to stabilize the streambanks by binding together soil particles, thereby reducing streambank erosion. In addition, the resultant riparian communities will contribute to flood control by storing water throughout the floodplain during high flows and releasing water slowly during low flow intervals.

6.2.2 Existing Conditions

Recent land management practices have resulted in the removal of the majority of woody vegetation from the north bank of the Colorado River. Seedlings of salt cedar, mesquite, western soapberry and some herbaceous plants, including Johnson grass, saltgrass, ragweed, and Mexican devil-weed, have colonized the area. Most of the north bank is devoid of native riparian vegetation and has become overrun with invasive herbaceous species. On the south bank, salt cedar dominates the riparian zone immediately adjacent to the river. In addition, there are mesquite, western soapberry, and other trees, shrubs and herbaceous plants within the river's flood-prone area. Within the river and on adjacent banks, wetlands comprised of sedge and cattails are also present. Figure 6.2.1 shows the areas that have been stripped of vegetation, current distribution of plant species along the subject reach, location of existing wetlands, and the areas of dense salt cedar. The invasion of the riparian system with salt cedar, as well as the vegetation management practices along the subject reach of the Colorado River, has resulted in a riparian system lacking adequate vegetation, sources of large woody debris, and the diversity of plant species usual in unmodified riparian corridors.

Soils Evaluation. An evaluation of the soils in the riparian area was conducted to characterize the site's physical and chemical condition and fertility levels. Sampling areas were determined based on similarities in vegetation, current management, topography and soil texture. Specific sampling sites were selected by the presence of soil and vegetation features that suggest a physical or chemical imbalance. Potential problem areas existing within the restoration area were recorded and mapped (i.e., excessive compaction, alkali or saline deposits, excessive disturbance, etc.).

Composite soil samples were collected at 7 sample points distributed across the riparian community restoration area. Each sample was composited by combining four individual sub-samples of a particular sampling interval depth. Discrete vertical samples were taken from the 0-6 inch, 6-12 inch and 12-24 inch soil horizon depth intervals at each sub-sample location. A soil profile description was recorded for each subsample location. Each composite sample was thoroughly mixed, labeled and sealed in plastic bags. The bags were placed in a cooler and sent to the soils testing laboratory for analysis.

The following is a description of each sampling site, as shown on Figure 6.2.1:

Site 1: Active floodplain dominated by saltgrass (zone 2)
Site 2: Active floodplain dominated by saltgrass, with salt deposits on the surface (zone 2)
Site 3: Active floodplain dominated by mature salt cedar (zone 2)
Site 4: Slope above active floodplain dominated by Johnson grass (zone 3)
Site 5: Slope above active floodplain dominated by Mexican devil-weed (zone 3)
Site 6: Active floodplain dominated by saltgrass, Mexican devil-weed, and Johnson grass (zone 2)
Site 7: Upper terrace dominated by Johnson grass and switch grass (zone 4)

Soil analytical data for the riparian restoration site are contained in Table 6.2.1. Each soil sample was characterized using the following parameters: texture,

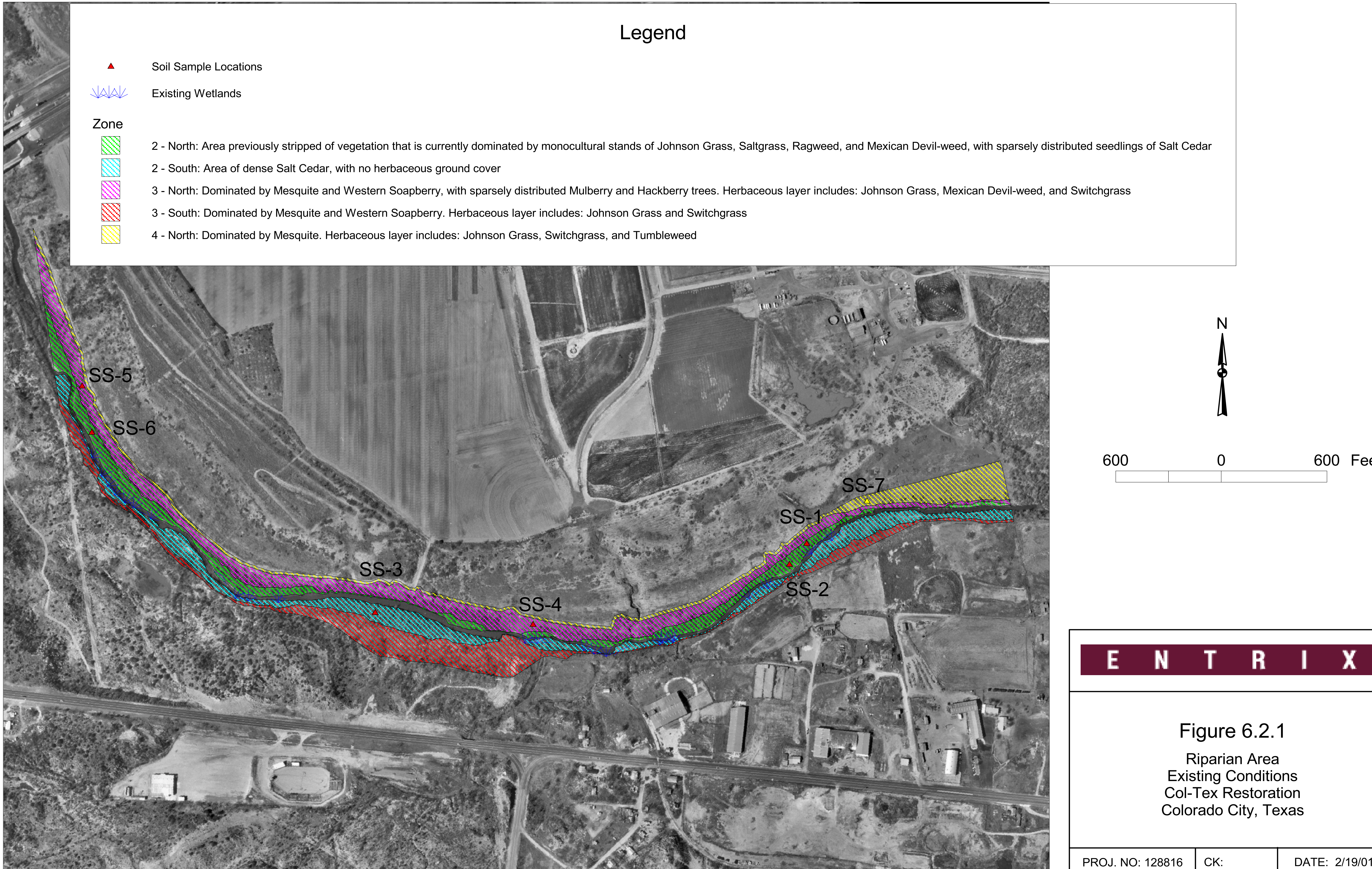


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Figure 6.2.1

Riparian Area
Existing Conditions
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 2/19/01

Table 6.2.1 – Soil Analytical Results, Riparian Restoration Area

Lab ID	Sample ID	Depth	Moisture		SP pH	SP EC	Soluble Cations			SAR	CEC	Plant Available Nutrients			Organic Matter
			As Rec'd	Sat. Paste			Na	Ca	Mg			NO_3-N	PO_4-P	K	
		in.	%	%	s.u.	mmhos/cm	meq/L	meq/L	meq/L		meq/100g	mg/kg	mg/kg	mg/kg	%
990478-01	RAPSOIL 1-1	0-6	35.6	69.2	7.3	24.0	189.1	23.4	38.3	34.1	22.6	1.2	66.5	512	2.7
990478-02	RAPSOIL 1-2	6-12	35.4	64.5	7.6	26.0	165.7	22.6	35.7	30.7	18.5	0.6	50.1	373	1.7
990478-03	RAPSOIL 1-3	12-24	28.6	46.3	7.8	24.4	163.5	24.3	34.7	30.1	13.5	0.6	32.3	302	1.2
990478-04	RAPSOIL 2-1	0-6	35.5	58.5	7.9	39.7	219.6	23.1	44.4	37.8	17.2	8.4	71.2	407	1.8
990478-05	RAPSOIL 2-2	6-12	28.4	36.6	8.0	25.6	185.7	25.3	37.9	33.0	9.8	0.5	40.8	258	1.0
990478-06	RAPSOIL 2-3	12-24	25.8	26.2	7.7	22.1	147.8	26.5	32.5	27.2	6.4	0.5	29.2	186	0.7
990478-07	RAPSOIL 3-1	0-6	17.8	72.4	7.6	4.5	22.5	11.2	3.8	8.2	33.9	40.6	67.8	833	3.1
990478-08	RAPSOIL 3-2	6-12	17.8	73.5	7.5	4.8	22.5	12.2	4.1	7.9	34.1	34.6	57.6	721	2.7
990478-09	RAPSOIL 3-3	12-24	20.4	58.1	7.5	10.2	41.0	30.0	10.3	9.1	22.8	19.3	41.1	532	1.8
990478-10	RAPSOIL 4-1	0-6	10.5	42.5	7.5	1.5	3.3	9.0	2.2	1.4	16.8	10.2	39.2	568	2.1
990478-10*	RAPSOIL 4-1 (D)	0-6	---	41.1	7.4	1.5	3.2	8.5	2.1	1.4	16.1	7.9	40.6	628	1.9
990478-11	RAPSOIL 4-2	6-12	7.8	42.9	7.5	1.4	3.0	8.6	2.1	1.3	12.0	4.5	28.9	407	1.2
990478-12	RAPSOIL 4-3	12-24	7.5	36.5	7.6	1.2	4.1	6.0	1.4	2.1	12.0	2.4	23.5	312	0.9
990478-13	RAPSOIL 5-1	0-6	10.4	48.1	7.5	1.8	5.7	8.9	2.0	2.5	18.1	9.2	48.0	579	2.1
990478-14	RAPSOIL 5-2	6-12	7.5	40.2	7.7	1.7	5.6	8.1	1.7	2.5	12.0	2.7	23.6	319	1.2
990478-15	RAPSOIL 5-3	12-24	6.2	36.0	7.7	2.5	11.5	11.9	2.8	4.3	10.0	1.8	16.3	260	0.7
990478-16	RAPSOIL 6-1	0-6	18.4	62.2	7.4	12.0	53.9	33.2	12.0	11.3	21.7	34.0	60.8	480	2.7
990478-17	RAPSOIL 6-2	6-12	22.5	61.4	7.5	9.6	43.4	24.1	9.6	10.6	20.8	31.7	45.7	422	2.0
990478-18	RAPSOIL 6-3	12-24	28.9	50.7	7.6	11.0	56.5	20.8	10.0	14.4	15.3	3.7	25.9	315	1.2
990478-19	RAPSOIL 7-1	0-6	34.2	50.6	7.6	2.2	5.6	13.6	3.3	1.9	19.0	25.5	58.8	682	2.5
990478-20	RAPSOIL 7-2	6-12	8.4	46.0	7.6	1.5	4.0	10.1	2.2	1.6	15.4	8.3	38.6	520	1.7
990478-20*	RAPSOIL 7-2 (D)	12-24	---	46.4	7.6	1.4	3.8	9.6	2.1	1.6	14.6	8.1	39.2	517	1.8
990478-21	RAPSOIL 7-3	12-24	5.7	37.9	7.7	1.2	3.3	8.0	1.5	1.5	11.3	3.0	22.5	294	1.0

Table 6.2.1, continued – Soil Analytical Results, Riparian Restoration Area

Lab ID	Sample ID	Textural Analysis				Munsell Color Test		Bulk Density	
		Sand %	Silt %	Clay %	Class	Color	Description	Volumetric g/cm^3	Clod Method g/cm^3
990478-01	RAPSOIL 1-1	24	38	38	CL	5YR 3/3	Dark reddish brown	1.2	1.3
990478-02	RAPSOIL 1-2	28	36	36	CL	5YR 3/3	Dark reddish brown	1.3	--
990478-03	RAPSOIL 1-3	49	25	26	SCL	5YR 3/3	Dark reddish brown	1.4	--
990478-04	RAPSOIL 2-1	26	44	30	CL	5YR 3/3	Dark reddish brown	1.3	--
990478-05	RAPSOIL 2-2	56	25	19	SL	5YR 3/3	Dark reddish brown	1.4	--
990478-06	RAPSOIL 2-3	66	18	16	SL	5YR 3/4	Dark reddish brown	1.6	--
990478-07	RAPSOIL 3-1	16	34	50	C	5YR 3/3	Dark reddish brown	1.3	--
990478-08	RAPSOIL 3-2	14	36	50	C	5YR 3/3	Dark reddish brown	1.3	--
990478-09	RAPSOIL 3-3	26	35	39	CL	5YR 3/2	Dark reddish brown	1.4	1.4
990478-10	RAPSOIL 4-1	42	26	32	CL	5YR 4/4	Reddish brown	1.3	--
990478-10*	RAPSOIL 4-1 (D)	42	26	32	CL	--	--	1.2	--
990478-11	RAPSOIL 4-2	50	26	24	SCL	5YR 4/4	Reddish brown	1.4	--
990478-12	RAPSOIL 4-3	49	29	22	L	5YR 4/4	Reddish brown	1.4	1.6
990478-13	RAPSOIL 5-1	34	36	30	CL	5YR 4/4	Reddish brown	1.4	--
990478-14	RAPSOIL 5-2	42	34	24	L	5YR 4/6	Yellowish brown	1.3	--
990478-15	RAPSOIL 5-3	51	33	16	L	7.5YR 4/6	Strong brown	1.3	--
990478-16	RAPSOIL 6-1	22	38	40	CL	5YR 3/3	Dark reddish brown	1.2	1.3
990478-17	RAPSOIL 6-2	31	35	34	CL	5YR 3/3	Dark reddish brown	1.3	1.4
990478-18	RAPSOIL 6-3	39	29	32	CL	5YR 3/3	Dark reddish brown	1.4	--
990478-19	RAPSOIL 7-1	40	30	30	CL	5YR 3/3	Dark reddish brown	1.4	--
990478-20	RAPSOIL 7-2	40	32	28	CL	5YR 4/4	Reddish brown	1.4	--
990478-20*	RAPSOIL 7-2 (D)	43	33	24	L	--	--	1.4	--
990478-21	RAPSOIL 7-3	52	30	18	SL	7.5YR 4/6	Strong brown	1.4	--

cation exchange capabilities, pH, sodium absorption ratio, organic matter content, and availability of nitrogen, potassium, and phosphorous.

The parent material and soils of the sampled sites along the Colorado River (Sites 1 through 7) consist primarily of fine textured material ranging from a sandy loam at Site 2 to finer loams, clay loams, and clay at the remaining sites. Sandier soils were associated with terraces and other depositional environments. The analytical results for soil texture suggest that the site is predominately clay loam. The cation exchange capabilities ("CEC") values for the riparian site are within normal ranges. The pH values for the upland site ranged from 7.3 to 8.0, which is typical for soils developed from finer textured parent materials. No visual indicators of calcareous soils were evident.

The saline/sodic content of soils in the riparian area is best estimated with the analytical tests for electrical conductivity ("EC") and sodium adsorption ratio ("SAR"). Sites 1 and 2 exhibited highly elevated soluble sodium values, which directly affected the EC and SAR values. While EC values of 4 to 12 mmhos/cm are generally marginal for plant establishment, values greater than 12 may impact plant establishment and survival. Finer textured clay-loam salt-affected soils are more difficult to reclaim than coarser textured sandy loam soils. SAR values greater than 8 in clayey soils and 12 in sandy loam soils may adversely impact plant establishment and soil structure. The EC and SAR values are elevated on Sites 3 and 6. However, the salt levels are not high enough to preclude the establishment of salt tolerant plant species.

Organic matter ("OM") analysis indicates the amount of residual plant by-products including roots, litter, and humic acids. The riparian area OM levels are normal for this type of active fluvial environment.

Samples were analyzed for availability of nitrogen, phosphorous, and potassium, to determine if amendments are necessary for vegetation establishment. The nitrate-nitrogen data range from a low of 0.5 mg/kg on Site 2 to a high of 40.6 mg/kg on Site 3. Sites 1, 2, 4, 5 and 7 have nitrate-nitrogen levels less than 15 mg/kg. These results suggest a nitrogen deficiency in the surface six inches. The phosphate values are not deficient and range from a low of 16.3 mg/kg to a high of 71.2 mg/kg. No amendments are necessary for potassium, with values ranging from a low of 186 mg/kg on Site 2 to a high of 833 mg/kg on Site 3.

6.2.3 Planned Action

There are five priorities for riparian enhancement as proposed for this site: salt cedar control, site preparation, irrigation system installation, native revegetation, and fencing installation. Details for each item follow.

Salt cedar Control. Salt cedar removal will be followed by revegetation with native riparian species. This action includes initiating salt cedar control on approximately 7.0 acres along the south side of the Colorado River and continuing salt cedar control efforts initiated by the TDCJ on approximately 6.0 acres along the north side of the Colorado River. Salt cedar control measures will include initial eradication efforts as well as on going, annual maintenance to control regrowth. Eradication efforts will include the cutting of stems of salt cedar to within 5 cm of the ground surface, followed by herbicide application to the area adjacent to the cambium and bark around the entire circumference of the cut stumps. An approved herbicide, such as Garlon4 or PathfinderII, will be used. In order to increase effectiveness of herbicide applications, salt cedar control measures will be performed in the fall when salt cedar trees translocate nutrients from their leaves and stems into their roots.

Site Preparation. In order to ensure the success of the restoration, site preparation will be undertaken prior to planting. Superficial solid wastes and debris will be removed from the site. Solid waste materials uncovered during excavation at the site will be buried within the project area or otherwise properly disposed of in accordance with TCEQ guidelines for solid waste management. Site preparation to prepare soil for seeding, control invasive herbaceous species, adding necessary soil amendments, seeding of a cover crop, and seeding of herbaceous riparian species will be completed in accordance with the restoration goals for riparian habitat enhancement outlined in Section 6.0. Invasive herbaceous species will be controlled to reduce competition between herbaceous species and seedlings and allow for greater riparian seedling survival. This may be accomplished both by tilling and by applying herbicide to affected areas of the project. Concurrently with this phase of the site preparation, necessary soil amendments will be incorporated to control soil salinity and enhance plant health and survival.

The site survey and soil analytical results suggest that the soils on certain sites of the study area may require a variety of organic, gypsum, sulfur and physical amendments to better establish canopy and under story vegetation. Table 6.2.2 provides an amendment and management matrix that has been developed after reviewing the site survey and soil analyses. The matrix summarizes chemical amendments, organic amendments and physical management inputs that may be required for each of the seven sampling sites. The primary goal in the use of amendments is to control high levels of salinity in the soil.

Elevated sodium, EC and SAR levels encountered at Sites 1 and 2 are a concern because of the finer textured soils present on these sites. It should be noted that these sites represented the most saline prone areas of the project reach and exhibited salt crusting on the surface. The goal is to reduce the exchangeable

Table 6.2.2 – Riparian Restoration Soil Amendment and Management Matrix

	Chemical Amendments					Organic Amendments		Physical Management			
Site	Nitrogen (lbs/acre)	Phosphorous (lbs/acre)	Potassium (lbs/acre)	Sulfur (tons/acre)	Gypsum (tons/acre)	Mulch	Amendments	Ripping	Disking	Crimping	Comments
1	40*	0	0		5.36	Surface mulch (2 tons native hay mulch or equiv.).			Disk to 6" to incorporate fertilizer, CaSO4 and prepare seedbed..	Crimp or land imprint mulch	Active floodplain dominated by saltgrass (zone 2)
2	40*	0	0	0.4	2.25	Surface mulch (2 tons native hay mulch or equiv.).	20 tons/acre incorporated OM.	Rip to 24" to reduce compaction & improve water infiltration	Disk to 6" to incorporate OM, fertilizer, Sulfur, CaCO3 and prepare seedbed.	Crimp or land imprint mulch	Active floodplain dominated by saltgrass, with salt deposits on the surface (zone 2)
3	20^	0	0			Surface mulch (2 tons native hay mulch or equiv.).	20 tons/acre incorporated OM.	Rip to 24" to reduce compaction & improve water infiltration	Disk to 6" to incorporate fertilizer OM and prepare seedbed.	Crimp or land imprint mulch	Active floodplain dominated by mature salt cedar (zone 2)
4	40*	0	0			Surface mulch (2 tons native hay mulch or equiv.).	20 tons/acre incorporated OM.		Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Slope above active floodplain dominated by Johnson grass (zone 3)
5	40*	0	0			Surface mulch (2 tons native hay mulch or equiv.).			Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Slope above active floodplain dominated by Mexican devil-weed (zone 3)
6	30^	0	0			Surface mulch (2 tons native hay mulch or equiv.).	20 tons/acre incorporated OM.		Disk to 6" to incorporate fertilizer and prepare seedbed.	Crimp or land imprint mulch	Active floodplain dominated by saltgrass, Mexican devil-weed, and Johnson grass (zone 2)
7	25*	0	0			Surface mulch (2 tons native hay mulch or equiv.).			Disk to 6" to incorporate fertilizer and prepare seedbed.	Crimp or land imprint mulch	Upper terrace dominated by Johnson grass and switch grass (zone 4)

*Note: Nitrogen amendments are to be applied in two applications. One application of 40# actual nitrogen per acre prior to seeding and one application of 40# later in the season after germination.
^Note: Nitrogen amendments are to be applied in one applications prior to seeding.

sodium percentage to 5 on these types of sites. On Site 1 applying 5.4 tons per acre of gypsum ($CaSO_4$) and discing to six inches will result in the replacement of sodium with calcium on the exchange sites. Since Site 2 exhibited pH values greater that 7.5, amending the area with 0.4 tons of sulfur and 2.25 tons of gypsum per acre and discing to six inches is recommended. Amending these sites with gypsum, sulfur and organic matter followed by deep ripping should promote water infiltration and dilution.

In addition to the amendments used to control salinity, varying amounts of fertilizers may be used for select areas. Low amounts of nitrogen (40 pounds of actual nitrogen per acre) may be applied to localized areas that will be densely planted to reduce weed competition and excessive under story growth that may reduce plant establishment. A second application may be made later in the season after the seedlings are established. Moderate amounts of organic matter (hay mulch or cotton burs) may be incorporated into Sites 2, 3, 4 and 6. The organic matter will improve water infiltration, nutrient availability and soil structure. Improved water infiltration will result in a reduced sodium level over time. The bulk density data suggest that soil compaction was not significant on the riparian site. However, ripping will also improve water infiltration and help incorporate organic amendments.

Following the addition of necessary soil amendments, a cover crop will be planted throughout the riparian restoration. A cover crop is a non-invasive crop planted to provide a natural, economical form of composting that serves to feed the soil when plowed under. A cover crop provides numerous benefits to the soil. A cover crop acts to protect the soil from water and wind erosion prior to planting of the desired native species. A cover crop adds to the organic matter of the soil, improves soil structure and water infiltration, and provides and conserves available nitrogen within the soil. In addition, a cover crop aides in the natural suppression of weed growth.

Site preparation will also include the seeding of herbaceous species such as: switch grass *(Panicum virgatum)*, little bluestem *(Schizachyrium scoparium)*, sideoats grama *(Bouteloua curtipendula)*, blue grama *(Bouteloua gracilus),* sand dropseed *(Sporobolus cryptandrus),* indiangrass *(Sorghastrum nutans)*, rush *(Juncus sp.)*, and bulrush *(Scirpus sp.).* Seeding of selected species will be done to control soil erosion and prevent the incursion of weedy species, as well as to provide a ground cover of native grass species that will not compete with later tree and shrub plantings.

<u>Irrigation System</u>. To increase transplant survival rates and enhance seedling growth, a subsurface drip irrigation system may be installed over the entire 21-acre project area to provide a reliable water source. The subsurface drip irrigation

system will be equipped with 1 gallon-per-hour emitters. Trees will receive an average of approximately 8 to 10 gallons per week for the first year. The irrigation system will be utilized for a period of three years, with the amount of irrigation gradually decreased during the second and third years. Climatic conditions and individual species water requirements will determine specific need for irrigation. Water will be obtained from wells on the project site.

Native Species Revegetation. Revegetation of the cleared riparian area with native woody tree, shrub, and herbaceous species is proposed for a 4,000-linear foot section of the Colorado River. Riparian enhancement includes approximately 10 acres along the south side and 11 acres along the north side of the river adjacent to the TDCJ facility, for approximately 21 total acres. Potential riparian species to be planted include: Eastern cottonwood (*Populus deltoides*), black willow (*Salix nigra*), hackberry (*Celtis occidentalis*), little walnut (*Juglans microcarpa*), pecan (*Carya illinoinensis*), mulberry (*Morus rubra*), western soapberry (*Sapindus drumondii*), fourwing saltbush (*Atriplex canescens*), aromatic sumac (*Rhus aromatica*), native plum (*Prunus angustifolia*), little-leaf sumac (*Rhus microphylla*), and catclaw acacia (*Acacia greggii*). These species have been chosen for their value in riparian habitats and their suitability for the restoration area, as indicated by their presence on the site.

Due to the large number of plants required, readily available nursery-grown material will be used for the majority of the plant species. Plant materials in the form of bare-root seedlings will be obtained from the Texas Forest Service as available, with the exception of the eastern cottonwood and black willow. The eastern cottonwood and black willow will be propagated by transplanting cuttings obtained from sources in the Colorado City area. Cuttings will be harvested by the end of January and planted by the end of February. Because bare-root seedlings must be planted while dormant, they will be planted from January through March. Conservation matting and tree shelters may be used to alleviate competition from herbaceous species and to protect the seedlings from herbivory.

Planting densities will vary along the reach. Dense clusters of riparian vegetation will be planted on either bank, separated by more sparsely vegetated areas and existing wetland areas. This mosaic will provide variability in the lateral pattern along the river. Figures 6.2.2a and 6.2.2b illustrate the mosaic that will be created by mixing sparse vegetation, dense vegetation, and existing wetland vegetation community areas. The pattern depicted on the figures provides a concept of the variability in planting densities. The goal of the planting plan will be to create a denser vegetative cover along the river channel, with cover becoming generally less dense moving uphill. Specific locations for the areas of denser vegetation will be determined based on topographic constraints, channel morphology, and outcrop locations. In addition, tree and shrub species will be planted within

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Figure 6.2.2 a

Riparian Planting Areas
West Side
Col-Tex Restoration
Colorado City, Texas

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Figure 6.2.2 b

Riparian Planting Areas
East Side
Col-Tex Restoration
Colorado City, Texas

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clusters of riparian vegetation in a pattern that will optimize vertical variation when the canopy is mature. Placement of specific plant species in relation to the river will be based upon growth characteristics and water needs of each species. Planting zones correspond to the topographically-defined zones, as described above. These zones are:

- Zone 1: Bottom of channel that is regularly inundated
- Zone 2: The active floodplain located above the channel
- Zone 3: Sloped sites that seldom flood
- Zone 4: Droughty upland sites

Zones of each tree and shrub species are shown in Table 6.2.3.

Table 6.2.3 – List of Riparian Tree and Shrub Species for Re-vegetation

Common Name	Scientific Name	Class	Zone
Eastern cottonwood	*Populus deltoides*	tree	2
Black willow	*Salix nigra*	tree	2
Bald Cypress	*Taxiodium distichum*	tree	2
Hackberry	*Celtis occidentalis*	tree	3,4
Little walnut	*Juglans microcarpa*	tree	3
Pecan	*Carya illinoinensis*	tree	2,3
Mulberry	*Morus rubra*	tree	3
Western soapberry	*Sapindus drumondii*	tree	3,4
Coralberry	*Symphoricarpos oreophilus*	shrub	2
Fourwing saltbush	*Atriplex canescens*	shrub	3,4
Aromatic sumac	*Rhus aromatica*	shrub	3,4
Native plum	*Prunus angustifolia*	shrub	2,3
Little-leaf sumac	*Rhus microphylla*	shrub	3,4
Catclaw acacia	*Acacia greggii*	shrub	3,4
White honeysuckle	*Lonicera albiflora*	vine	2
Woodbine	*Parthenocissus heptaphylla*	vine	2

Average planting densities will be approximately 450 plants per acre with ten-foot spacing in denser areas and approximately 120 plants per acre with twenty-foot spacing in sparsely vegetated areas. The ratio of trees to shrubs will be specific for each planting zone and are based upon the goals and objectives set for the restoration of the riparian corridor. In zone 2, the primary objective is to increase shade along the river, which will in turn improve local water quality. Shade along the river will be best achieved by creating a canopy of trees along the reach in zone 2. The ratio of trees to shrubs in zone 2 will be generally 90% trees and 10%

shrubs. In zone 3, the primary objectives are to revegetate the riparian corridor using native riparian species and to increase habitat diversity for forage and cover along the project reach. This will be accomplished by utilizing a variety of native tree and shrub species. They will be planted along zone 3 in a mosaic to optimize vertical variation and create microhabitats within the riparian corridor. The approximate ratio of trees to shrubs in zone 3 will be 60% trees to 40% shrubs. In zone 4, the primary objective is to create a windbreak or buffer zone that will protect and provide a transition from the surrounding landscapes to the riparian corridor. This will be accomplished by planting a row of trees adjacent to the slope break of the riparian corridor followed by a row of shrubs uphill at the edge of the surrounding fields. The approximate ratio of trees to shrubs in zone 4 will be generally 50% trees to 50% shrubs. Within each planting zone, species diversity will be maximized through proper species selection and placement.

Based upon the delineation of zones, acreages of each management unit are shown in Table 6.2.4.

Table 6.2.4 – Riparian Zones, Proposed Planting Density, and Acreages

Zone	Planting Density	Acres
2	Dense	3.1
2	Sparse	3.6
2	None (conservation)	0.4
3	Dense	5.6
3	Sparse	5.8
4	Dense	2.1
4	Sparse	0.8
	TOTAL	**21.4**

See Figures 6.2.2a and 6.2.2b for delineation of zones and management units.

Fencing. While the TDCJ does not graze cattle on their property, there are horse grazing activities on the north side of the river that may impact the success of the project. Fencing will be provided along the north side of the project area to prevent horses from entering the area. This fencing will consist of three-strand wire and wooden posts. The maximum total length of fencing on the north side of the river will be 5,000 linear feet. Exclusion fencing will not be installed along the riparian area on the south side of the river since there will be no grazing activities on the southern upland parcel.

6.2.4 Timing of Activities

The restoration of the riparian corridor involves a three-year plan as described below and shown on Figure 6.2.3. A phased approach involving planting over a two-year period was chosen to ensure availability of locally grown, native plant materials in sufficient quantity. To the extent possible, the first year of planting will focus on zone 2 planting areas, utilizing cuttings from local sources for propagation of eastern cottonwood and black willow**.**

1st Year
3rd and 4th Quarter:

- Fencing Installation
- Salt cedar removal over the entire project area
- Tilling and herbicide application of areas dominated by invasive herbaceous species
- Soil amendments in areas of concern
- Seeding with a nurse crop of cool-season grasses

2nd Year
1st Quarter:

- Installation of subsurface drip irrigation system
- Phase I: Planting of approximately 3200 bare-root seedlings and eastern cottonwood and black willow cuttings over approximately 12 acres of the riparian project area.
- Seeding of herbaceous species over the entire project area
- Mulching, as needed

See Figure 6.2.3 for an illustration of areas to be planted during the second year.

3rd Quarter:

- Follow up on the removal of salt cedar that has resprouted

3rd Year
1st Quarter:

- Phase II: Planting of approximately 3200 bare-root seedlings over 9 acres of the riparian project area
- Mulching, as needed

See Figure 6.2.3 for an illustration of the project area after the third year planting

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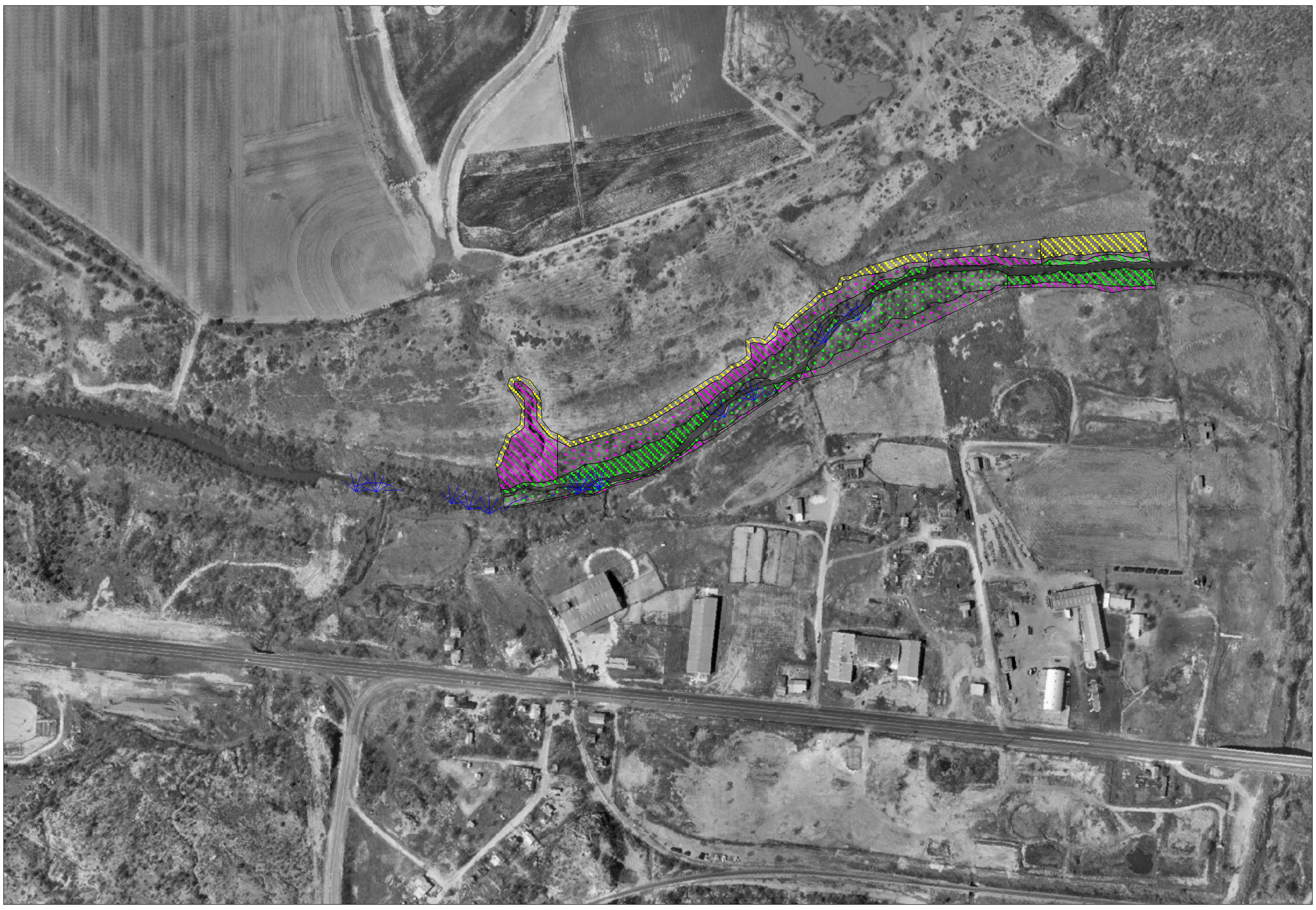
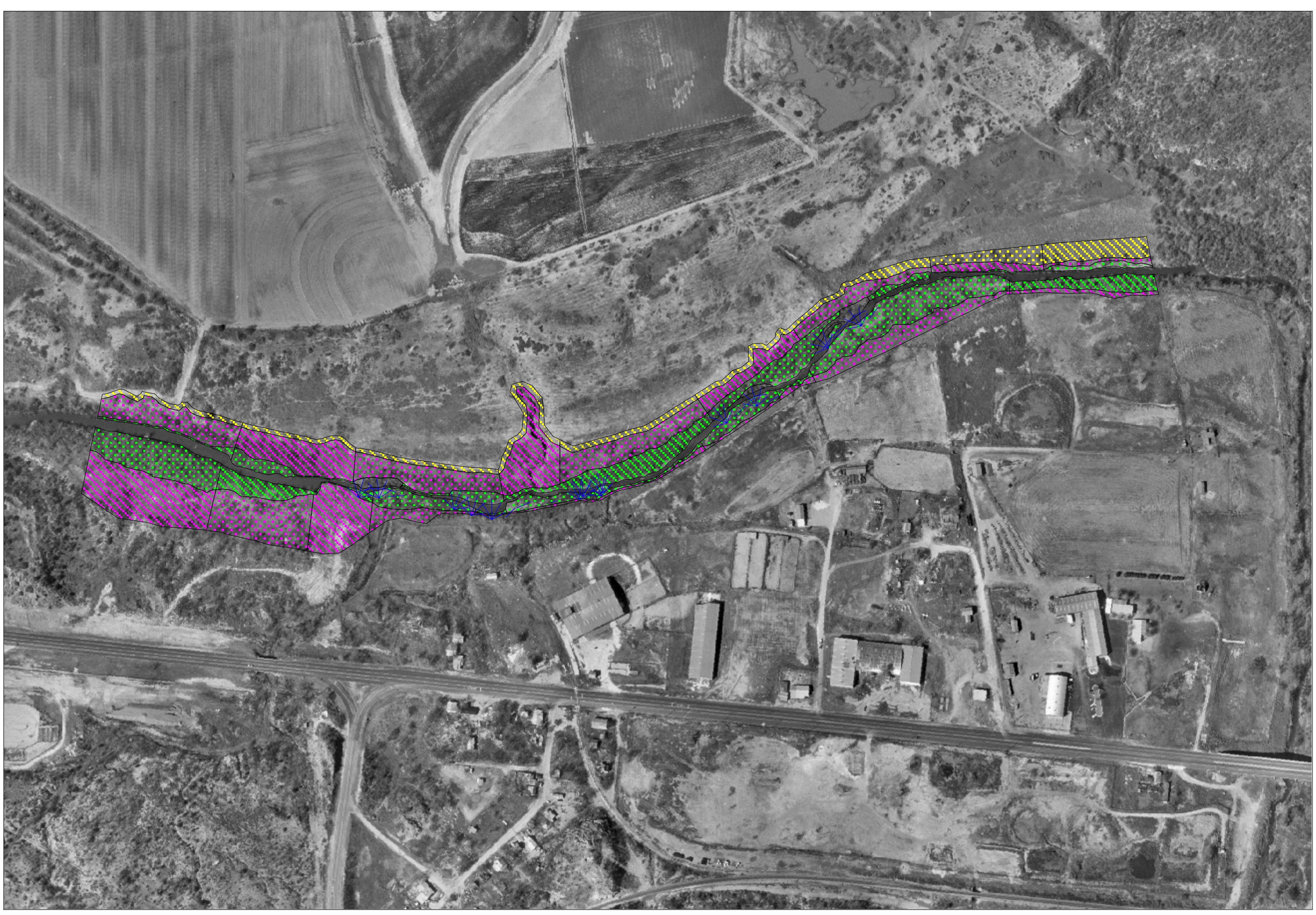


Year 2



Year 3

Legend

Existing Wetlands

Planting Zone

- 2 Dense
- 2 Sparse
- 2 None
- 3 Dense
- 3 Sparse
- 4 Dense
- 4 Sparse

N

500 0 500 Feet

E N T R I X

Figure 6.2.3

Phased Approach to Planting
Conceptual Model
Col-Tex Restoration
Colorado City, Texas

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6.3 Restore Native Scrub/Shrub Habitat

The goal as stated in Section 6.0 is to restore and enhance a native upland scrub/shrub vegetative community. The objectives for this goal are:

- Conserve approximately 60 acres of upland scrub/shrub and native grassland habitat south of the Colorado River;
- Revegetate former cropland, rangeland, and industrial property in native upland species that would increase local diversity;
- Provide a greater diversity of upland plant species in the area;
- Control soil erosion and runoff on the site; and
- Provide a fertile, stable growth medium to germinate, establish and grow plant species.

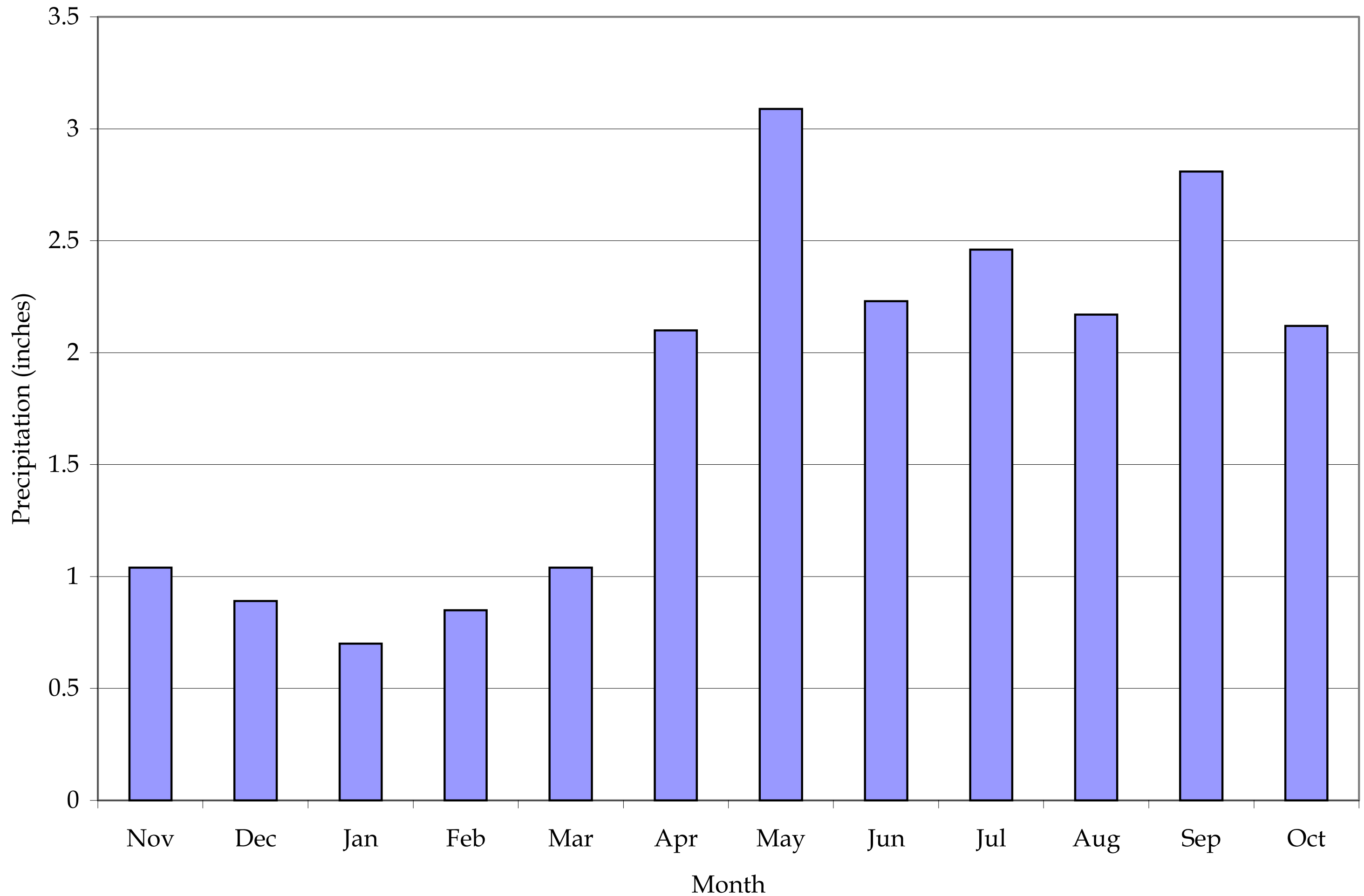
6.3.1 Background

Local climatic and environmental conditions directly impact and influence the plant species and vegetation communities that grow and develop within a specific region. The climate at this site is characteristic of semi-arid lands in west central Texas. Temperatures range from a low of 0^{o} F to an average daily maximum in August of 97^{o} F. The growing season is approximately 219 days in length. Rainfall averages 19.9 inches per year. Average monthly precipitation by month for the precipitation period of record is depicted on Figure 6.3.1. The lower portion of the upland restoration area, along the Colorado River's upper terrace (corresponding to zone 4 in the riparian discussion), may be subjected to periodic flooding, particularly during the rainy season.

Precipitation is relatively uniform in its average monthly distribution during the growing season, ranging from a low of slightly more than 2 inches in April and October to a high of slightly more than three inches in May. Typically, almost 80% of the annual precipitation is received between April and October. Spring, summer, and early fall precipitation is generally received from localized thunderstorms. Unsettled weather patterns and more general rains occur from late fall through early spring of each year.

Slope and aspect primarily affect plant growth due to their influence on net solar insolation and related variations in evapotranspiration rates, and soil and air temperatures. Slope and aspect on this site will play an important role in the types of plant communities that may be restored. The upland restoration area is oriented lengthwise in an east-west direction with its primary aspect being north. North-facing slopes are generally cooler, have lower evapotranspiration rates and tend to have moister soil conditions than their counterpart slopes with south facing slopes.

Figure 6.3.1 – Average Precipitation by Month, Colorado City, Texas



The upland area is classified as a Rough Breaks Range Site by the NRCS classification system (U.S. Department of Agriculture, 1969). The area has a capability rating of Dryland VIIs-2. Within this range site, slopes normally range from 5 to 30 percent. The soil type prevalent throughout the area is Rough Breaks (Ro). Sandstone boulders and caliche are scattered over most areas, with rims of these materials prominent along tops of slopes. V-shaped gullies frequently dissect the Rough Breaks Range site. Badland topography characteristic of deeply eroded gullies and remaining ridges occurs in spots throughout this range site within Mitchell County. Where soil is adequate and proper management is practiced, good grass cover is normally present. Steep escarpments and severely eroded areas (scalds) below the escarpments may occur through out the range site. Native plant cover is highly variable and may be locally sparse, given the native soil characteristics, climate and topography.

Wildlife found in the region includes white-tailed deer, blue quail, bob white quail, mourning dove, fox, raccoon, skunk, coyote, and rattlesnake. Wildlife corridors that provide topographic and vegetative cover are of high value, particularly in and around more densely populated areas and in the proximity of agricultural fields that are cropped. In these areas, scrub-shrub vegetation communities provide critical habitat elements, as well as wildlife corridors through developed areas. A Rough Breaks Range site is capable of providing habitat for wildlife, particularly when management focuses on this purpose.

The following sections describe the existing conditions of soil erosion, soil chemistry and fertility, and vegetation on the site, and outline the proposed actions for upland habitat restoration.

6.3.2 Existing Conditions

The existing condition of soils, surface water drainage, and vegetation within the 25-acre upland restoration area are described as follows.

Soils Evaluation. Composite core samples were taken to characterize and describe current soil conditions. Soil Analytical Services, Inc. in College Station, TX performed soil laboratory tests to evaluate and characterize the site's physical/chemical condition and fertility levels. Prior to soil sampling, the upland scrub-shrub restoration area was surveyed to identify soil sample areas. Similarities in vegetation, current management, topography and soil texture were evaluated to determine the sampling area boundaries. Potential problem areas existing within the restoration area were recorded and mapped (i.e., excessive compaction, alkali or saline deposits, excessive disturbance, etc.).

Composite soil samples were collected at a density of approximately 1 per 2.25 acres, which correlates to 11 sample points distributed across the 25-acre scrub-shrub community restoration area. Each composite sample consisted of four individual sub-samples. Sub-sample locations were located on the four secondary cardinal points of the compass approximately in the center of their respective sub-sample quadrat. Discrete vertical samples were taken from the 0-6 inch, 6-12 inch and 12-24 inch soil horizon depth intervals at each composite sub-sample location. Each composite sample was thoroughly mixed, labeled and sealed in plastic bags. The bags were placed in a cooler and sent to the soils testing laboratory for analyses.

The following is a description of each sampling site, as shown on Figure 6.3.2:

- Site A: Access road and drill pad site
- Site B: Pipeline disturbance area along Business I-20
- Site C: Building site cleared of debris and leveled
- Site D: Parking lot adjacent to former cotton compress facility
- Site E: Agricultural field
- Site F: Agricultural field
- Site G: Partially irrigated pasture
- Site H: Remediated North Pond
- Site I: Irrigated pasture
- Site J: Remediated pasture
- Site K: Johnson grass "island"

Soil analytical data for the upland restoration site are contained in Table 6.3.1. The analytical results for soil texture suggests that the site is predominately sandy loam to loam. None of the sampled sites had high amounts of clay or sand; however, sites A, D, and I with coarser textured soils had slightly lower cation exchange capacities ("CEC"). The CEC values for the upland site were within normal ranges.

The pH values for the upland site ranged from 7.3 to 8.0 which is typical for soils developed from coarse textured alluvial deposits. Fizz testing with 5% HCl acid suggested the slight presence of carbonates in the soil. No visual indicators of calcareous soils were evident.

The saline/sodic content of the upland site is best estimated with the analytical tests for electrical conductivity ("EC") and sodium adsorption ratio ("SAR"). Only upland Sites B, H, and I exhibited slightly elevated soluble sodium values, which directly affected the EC and SAR values. Elevated sodium levels encountered at Sites H and I are at moderate levels and should not be a concern because of the coarser textured sandy loam soils. The elevated levels at Site I

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Figure 6.3.2

Upland Soil Sampling Areas
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 2/19/01

Table 6.3.1 – Soil Analytical Results, Upland Restoration Area

Sample ID		**Lab ID**	**Moisture**		**SP pH**	**SP EC**	**Soluble Cations**			**SAR**	**CEC**	**Plant Available Nutrients**			**Organic Matter**	**Textural Analysis**			
Site	**Depth in.**		**As Rcvd %**	**Sat. Paste %**	**s.u.**	**mmhos/cm**	**Na meq/L**	**Ca meq/L**	**Mg meq/L**		**meq/100g**	**NO_3-N mg/kg**	**PO_4-P mg/kg**	**K mg/kg**	**%**	**Sand %**	**Silt %**	**Clay %**	**Class**
A#1	0-6	990479-1	5.7	26.4	7.4	1.0	1.0	5.6	1.3	0.6	7.2	7.3	8.1	124	0.5	73	17	10	SL
A#2	6-12	990479-2	3.3	28.7	7.7	0.5	1.0	2.8	0.8	0.7	7.4	0.7	7.6	114	<0.3	67	22	11	SL
A#3	12-24	990479-3	3.1	24.6	7.7	0.5	1.5	2.2	0.7	1.3	5.9	0.4	8.2	109	0.4	69	23	8	SL
B#1	0-6	990479-4	4.9	39.4	7.6	3.2	13.9	8.5	3.1	5.8	11.1	12.1	8.8	227	---	49	27	24	SCL
B#2	6-12	990479-5	5.7	47.2	7.6	7.4	33.4	16.7	8.2	9.5	14.9	18.2	8.5	202	1.1	31	41	28	CL
B#3	12-24	990479-6	7.3	45.0	7.5	13.3	56.1	37.7	20.1	10.4	15.1	35.9	10.4	176	0.4	33	39	28	CL
C#1	0-6	990479-7	6.7	36.4	7.5	2.4	1.7	16.7	2.8	0.5	12.2	59.8	38.5	475	3.1	43	40	17	L
C#2	6-12	990479-8	5.3	38.2	7.3	2.8	3.0	19.9	3.6	0.9	12.6	57.1	22.2	267	1.5	47	34	19	L
C#3	12-24	990479-9	4.9	35.0	7.4	1.5	1.4	10.4	2.2	0.6	11.0	25.9	13.2	223	0.6	33	51	16	SiL
D#1	0-6	990479-10	15.8	29.5	7.6	1.9	5.7	11.1	2.0	2.2	7.2	20.3	33.6	216	1.6	61	28	11	SL
D#1(D)	0-6	990479-10*	---	29.8	7.6	1.9	5.6	10.9	1.9	2.2	6.9	19.7	37.1	228	1.6	65	27	8	SL
D#2	6-12	990479-11	3.9	27.5	7.6	0.7	1.4	4.4	0.7	0.9	7.4	5.1	17.5	164	0.9	63	27	10	SL
D#3	12-24	990479-12	3.2	27.0	7.8	0.7	1.3	4.1	0.7	0.8	5.6	2.7	7.8	83	<0.3	68	23	9	SL
E#1	0-6	990479-13	5.9	28.9	7.7	1.3	2.9	7.0	1.8	1.4	8.6	24.6	23.8	260	<0.3	61	26	13	SL
E#2	6-12	990479-14	4.7	27.1	7.7	0.7	1.6	4.2	0.9	1.0	7.4	9.0	14.6	179	0.9	61	29	10	SL
E#3	12-24	990479-15	6.8	35.5	7.6	1.4	4.3	7.4	2.5	1.9	11.7	25.9	67.8	355	<0.3	33	49	18	L
F#1	0-6	990479-16	8.0	32.4	7.4	1.0	2.2	5.3	1.1	1.2	9.2	13.3	14.9	215	0.8	53	32	15	SL
F#2	6-12	990479-17	7.3	36.6	7.6	0.9	2.0	5.0	1.2	1.1	10.7	10.3	33.3	228	<0.3	51	33	16	L
F#3	12-24	990479-18	7.7	37.8	7.6	0.9	2.1	5.9	1.0	1.1	11.0	9.3	21.8	182	0.6	53	31	16	SL
G#1	0-6	990479-19	9.7	44.0	7.5	1.8	4.2	8.6	3.0	1.8	15.2	43.3	96.6	327	4.6	47	38	15	L
G#2	6-12	990479-20	8.0	34.7	8.0	1.1	3.2	5.0	1.3	1.8	11.0	7.6	97.4	311	3.5	53	31	16	SL
G#2(D)	6-12	990479-20*	---	34.4	8.0	1.0	3.1	4.7	1.3	1.8	11.0	7.2	93.3	322	3.6	51	36	13	L
G#3	12-24	990479-21	9.1	34.3	7.7	0.9	2.9	3.9	1.2	1.8	10.2	4.2	38.6	246	3.4	49	34	17	L
H#1	0-6	990479-22	14.1	40.2	7.6	3.5	8.7	14.0	6.6	2.7	13.0	20.1	111.3	521	5.2	53	34	13	SL
H#2	6-12	990479-23	12.2	35.2	7.5	4.6	9.5	22.6	11.8	2.3	10.6	10.1	68.2	571	6.5	59	26	15	SL
H#3	12-24	990479-24	10.4	31.9	7.6	5.0	11.8	23.0	10.2	2.9	9.0	7.5	56.4	529	4.2	54	34	12	SL
I#1	0-6	990479-25	8.5	30.7	7.8	1.5	7.5	4.8	3.1	3.8	7.1	10.8	159.5	356	1.4	69	23	8	SL
I#2	6-12	990479-26	7.7	26.3	8.0	1.2	6.3	2.6	1.3	4.5	6.0	2.4	64.6	408	0.6	65	27	8	SL
I#3	12-24	990479-27	11.1	25.9	8.0	1.3	7.5	3.7	0.9	5.0	6.3	1.1	35.6	613	0.4	65	24	11	SL
J#1	0-6	990479-28	7.0	40.8	7.5	1.1	1.5	7.6	1.4	0.7	14.0	8.5	77.4	526	3.4	44	36	20	L
J#2	6-12	990479-29	6.2	35.4	7.6	0.9	0.8	4.7	1.5	0.5	9.2	5.7	84.6	517	5.2	53	28	19	SL
J#3	12-24	990479-30	4.7	33.0	7.5	0.8	0.8	4.6	1.6	0.4	8.3	4.5	176.0	366	5.6	53	34	13	SL
J#3(D)	12-24	990479-30*	---	32.4	7.4	0.8	0.8	4.8	1.6	0.5	9.7	4.7	178.7	387	5.6	53	34	13	SL
K#1	0-6	990479-31	14.0	48.6	7.3	1.4	1.1	9.5	1.9	0.5	17.8	13.4	16.8	510	3.4	33	38	29	CL
K#2	6-12	990479-32	9.3	39.2	7.4	0.8	0.7	6.4	1.2	0.4	13.1	4.1	13.8	366	2.5	45	35	20	L
K#3	12-24	990479-33	5.2	33.3	7.5	1.0	2.6	5.5	1.1	1.4	7.5	0.8	7.6	179	0.7	52	38	10	SL

may be the result of irrigation water containing high salt concentrations. While EC values of 4 to 12 mmhos/cm are generally marginal for plant establishment, coarser textured sandy loam soils are not as adversely affected by high EC values as clay or clay loam soils. SAR values greater than 8 in clayey soils and 12 in sandy loam soils may have a deleterious effect on plant establishment. Site B's sandy clay loam and clay loam textured soils may be affected by these elevated EC and SAR values (NMEMNR Dept., 1990).

Organic matter ("OM") analysis indicates the amount of residual plant by-products including roots, litter, and humic acids. OM values for Sites H and J are elevated relative to other sites. Sites A, B, D, E, F, and I have very low OM values and may require organic amendments.

Plant available nutrients of nitrogen, phosphorous, and potassium were tested to determine if amendments are necessary for vegetation establishment. The nitrate-nitrogen data for the 0-6 in. samples range from a low of 7.3 mg/kg on Site A to a high of 59.8 mg/kg on Site C. Sites A, B, F, I, J and K have nitrate-nitrogen levels less than 15 mg/kg which suggest a nitrogen deficiency in the surface six inches. The phosphate values for the 0-6 in. samples range from a low of 8.1 mg/kg to a high of 159.5 mg/kg. Sites A and B have plant available phosphate levels that suggest a deficiency. The potassium values for the 0-6 in. samples range from a low of 124 mg/kg on Site A to a high of 526 mg/kg on Site J.

<u>Surface Water Runoff Conditions</u>. Site inspection and analysis indicates that the soil materials have medium to coarse textures. The soils have fair to good infiltration rates and are low to moderate in terms of susceptibility to erosion from surface sheet flows. Organic material content is low throughout most of the upland restoration area, which reduces soil resistance to surface erosion processes. There are a number of active and potential erosion problem areas on the property resulting from concentrated runoff flow that will need to be addressed during the implementation phase of the project. These areas include the agricultural terrace on the far-east side of project site, the dump area north of the old cotton compress facility, and fields showing evidence of excessive rilling. When final restoration topography is achieved, these areas should be evaluated for adequacy of their surface water runoff control and drainage systems.

<u>Vegetation Evaluation</u>. A pedestrian survey of the property was performed to inventory potential restoration species in adjacent scrub-shrub vegetation communities and evaluate their potential use on this site. Where present, undesirable plant species were characterized and mapped within the restoration area. The only species found in the project site that may be considered a nuisance is Johnson grass, which apparently has been planted in the past across a significant portion of the upland restoration area for agricultural purposes.

Johnson grass is capable of creating monocultures in areas favorable to its growth. This grass species has spread into adjacent undisturbed areas from past agricultural plantings. In particular, a monoculture of Johnson grass grows in one large field on the northwest side of the upland restoration site area (Area K on Figure 6.3.2). This area represents a potentially valuable upland habitat that currently has little habitat value.

6.3.3 Planned Action

The restoration and conservation of approximately 60 acres of upland habitat located adjacent to the restored Colorado River riparian corridor will result in a diverse mosaic of native vegetation communities. Approximately 35 acres of upland habitat on the south prison property is currently vegetated with native scrub/shrub species and mesquite. This acreage will be placed in a conservation easement. In addition, approximately 25 acres located at the eastern end of the project site will be restored to an upland vegetative community, using native forb, grass, and shrub species. Of that 25 acres, approximately 7 acres will be planted in shrub and tree species.

There are seven priorities for native scrub-shrub habitat restoration, as proposed for this site: surface grading and erosion control, undesirable species control, soil preparation and amendments, seedbed preparation, native revegetation – seeding, and native revegetation – transplanting, and mulching. Details for each item follows.

<u>Surface Grading and Erosion Control</u>. A master plan for surface water drainage will be prepared for the restoration area. This plan will consider the topography after solid waste materials uncovered during excavation at the site are buried with the project area or otherwise properly disposed of in accordance with TCEQ guidelines for solid waste management. Any superficial solid wastes and debris will be removed from the site to accommodate soil preparation for seeding. In the upland restoration area, soils appear to have good infiltration rates and relatively non-erosive textures. There are no excessively long slopes that require the placement of gradient terraces of diversion berms to reduce slope lengths. Therefore, the use of seedbed surface roughening methods in combination with mulching, as described below, should provide effective short-term control of surface erosion during plant germination and establishment periods. Control of minor concentrated flows that enter the restoration project area from the south may be accomplished using flow-spreading devices.

<u>Undesirable Species Control.</u> Prior to initiation of permanent upland vegetation restoration activities, the area will be surveyed for weedy plant species. Any weedy species found growing on the site will be controlled and eradicated using proper weed management control methods. The area infested with Johnson grass

on the west end of the upland area will be given particular attention during clearing operations. It is recommended that the Johnson grass growing in Area K be removed using approved herbicides in accordance with all federal, state and local laws and regulations.

Soil Preparation and Amendments. The site survey and soil analytical results suggest that the soils on selected sites of the study area will require chemical and organic amendments to establish shrub and under story vegetation and control erosion. Table 6.3.2 contains an amendment and management matrix that has been developed after reviewing the site survey and soil analyses. The matrix summarizes chemical amendments, organic amendments and physical management inputs recommended for each of the eleven sites.

To recondition damaged soils and alleviate excessive compaction, custom-formulated fertilizers and structural amendments will be applied and other augmentative work performed, as necessary. In alleviating compaction, particular attention will be paid to field access routes and trails. Moisture capacity in Rough Breaks Range soils is limited, but water availability for plant use is generally good. To enhance the absorption of moisture into the soil during the upland vegetation and establishment period, surface roughening will be conducted.

Fertilizer amendments are proposed for upland shrub sites except Site C. Nitrogen application will be in low amounts to avoid the enhancement of weed growth and excessive under story growth. The approach should reduce competition that might reduce shrub establishment. It is proposed that moderate amounts of organic matter (shredded hay mulch) be incorporated into sites A, B, D, E, F and I at rates between 20 and 30 tons per acre. The organic matter will improve water infiltration, nutrient availability and soil structure. Compaction was observed to a depth of 24 inches on Sites B, C, D, F, I and K. These sites will be ripped to improve water infiltration and help incorporate organic amendments.

Elevated sodium, EC, and SAR levels encountered at Site B may be a concern because of the finer textured soils at this site. The proposed ripping and organic matter amendments should promote water infiltration and dilution. Salt tolerant under story and shrub species will be seeded to improve vegetation establishment.

A cover crop may be planted in the upland restoration area, following surface grading. A cover crop is a non-invasive crop planted to provide a natural, economical form of composting that serves to feed the soil when plowed under. A cover crop provides numerous benefits to the soil. A cover crop acts to protect the soil from water and wind erosion prior to planting of the desired native species. A cover crop adds to the organic matter of the soil, improves soil structure and water infiltration, and provides and conserves available nitrogen

Table 6.3.2 – Upland Restoration Soil Amendment and Management Matrix

Site	Chemical Amendments			Organic Amendments		Physical Management			Comments
	Nitrogen* (lbs/acre)	Phosphorous (lbs/acre)	Potassium (lbs/acre)	Mulch	Amendments	Ripping	Disking	Crimping	
A	40	30	0	Surface mulch (2 tons native hay mulch or equivalent).	20-30 tons/acre incorporated OM.		Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Drill pad & access road. Low fert, low OM, sandy. No compaction
B	40	30	0	Surface mulch (2 tons native hay mulch or equivalent).	20-30 tons/acre incorporated OM.	Rip to 24" to reduce compaction & improve water infiltration	Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Pipeline disturbance. Low fert, low OM, gravelly clay loam. Elevated EC & SAR. Compaction to 24"
C	0	0	0	Surface mulch (2 tons native hay mulch or equivalent).		Rip to 24" to reduce compaction.	Disk to 6" to prepare seedbed.	Crimp or land imprint mulch	Leveled building site. Compacted at sub-sample sites 1, 2, & 3.
D	40	0	0	Surface mulch (2 tons native hay mulch or equivalent).	20 tons/acre incorporated OM.	Rip to 12" to reduce compaction.	Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Parking lot & turn around. Compacted at sub-sample sites 1, 2, 3, & 4. Coarse fragments at sub-sample 4.
E	40	0	0	Surface mulch (2 tons native hay mulch or equivalent).	20-30 tons/acre incorporated OM.		Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Cultivated wheat. Gravelly throughout profile. Sub-sample 4 compacted at 12-24".
F	40	10	0	Surface mulch (2 tons native hay mulch or equivalent).	20-30 tons/acre incorporated OM.	Rip to 24" to reduce compaction at lower 1/3 of slope.	Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Cultivated wheat. Upper 2/3 is irrigated. Sub-sample site 4 is compacted to 24".
G	40	0	0	Surface mulch (2 tons native hay mulch or equivalent).			Disk to 6" to incorporate fertilizer and prepare seedbed.	Crimp or land imprint mulch	Loamy, cultivated haygrazer. PET staining and debris.
H	40	0	0	Surface mulch (2 tons native hay mulch or equivalent).			Disk to 6" to incorporate fertilizer and prepare seedbed.	Crimp or land imprint mulch	North Pond site. Slightly elevated EC. PET staining and debris throughout sampled profiles.
I	40	0	0	Surface mulch (2 tons native hay mulch or equivalent).	20 tons/acre incorporated OM.	Rip to 24" to reduce compaction at lower 1/2 of slope.	Disk to 6" to incorporate fertilizer and OM and prepare seedbed.	Crimp or land imprint mulch	Terraced and irrigated pasture on sub-sample 1 & 2. Compacted on sub-sample 3 & 4. Small saline seeps noted downslope from irrigation.
J	40	0	0	Surface mulch (2 tons native hay mulch or equivalent).			Disk to 6" to incorporate fertilizer and prepare seedbed.	Crimp or land imprint mulch	Weedy pasture. Compacted on subsample sites 1, 3 and 4. Pet staining and debris throughout sampled profiles.
K	40	10	0	Surface mulch (2 tons native hay mulch or equivalent).		Rip to 24" to reduce compaction.	Disk to 6" to incorporate fertilizer and prepare seedbed.	Crimp or land imprint mulch	Johnsongrass. Compacted.

within the soil. In addition, a cover crop aides in the natural suppression of weed growth.

Seedbed Preparation. When soil restoration work has been completed, revegetation of the site can be undertaken. Revegetation will involve the preparation of suitable seed and transplant beds. Seedbeds will be prepared to facilitate native-plant seedling germination and establishment. Seedbeds will be left in a rough surface condition whenever possible. Areas will be seeded as soon as possible after completion of soil reconstruction. If the soil surface becomes encrusted or excessively sealed prior to seeding operations, appropriate agricultural practices will be used to alleviate crusting. Physical soil manipulation and revegetation operations (particularly those with linear physical characteristics) will be performed on the contour to the fullest extent possible to minimize potential surface erosion. When contour furrowing is utilized for surface roughening, it will be performed immediately prior to seed application.

Surface roughening will be used across the restoration area. Surface roughening will be accomplished using appropriate implements (shank rippers, discs, plows, furrowers or land imprinters). Roughening will provide topographic microhabitats that favor the establishment of the various plant species contained in the seed mixtures. Roughening will also serve to capture and retain precipitation. This in turn will serve to improve soil moisture content, which can be limiting in the Rough Breaks soil type. Increased soil moisture resulting from surface roughening can be expected to enhance plant germination, establishment and growth. Soil pedological processes will also benefit from surface roughening and its associated benefits.

Vegetation Community Restoration – Seeding. Seed mixtures will be planted using an appropriate combination of drilling and broadcast seeding methods. A typical seed mixture is contained in Table 6.3.3. The proposed upland seed mixture includes a variety of grasses, forbs and shrubs that are capable of being established from seed using modern land reclamation methods and practices. Given the size and nature of this site it is anticipated that only one seed mixture will be required to restore scrub-shrub habitat. This seed mixture may be divided into three sub-mixtures to ensure the even distribution of plant seed materials across the restoration area. Seed will be applied at a rate that approximates 15-20 pure live seeds (pls) per square foot. Bulk application rates will be calculated based on the purity and germination rates for the specific seed lots used in the mixtures. Application rates will be adjusted appropriately if the use of extenders is required.

Mulching. The purpose of mulching is to conserve moisture, prevent surface compaction or soil crusting, control weeds, aid in establishing plant cover, and

Table 6.3.3 – Upland Vegetation Community Restoration Seed Mixture

Species	Common Name	Desired % of Seed Mix (PLS)
Grasses		
Andropogon gerardii	Big bluestem	6%
Bouteloua curtipendula	Sideoats grama	5%
Bouteloua gracilis	Blue grama	5%
Buchloe dactyloides	Buffalo grass	5%
Sorghastrum nutans	Indiangrass	5%
Panicum virgatum	Switchgrass	6%
Setaria macrostachya	Plains bristlegrass	5%
Schizachyrium scoparium	Little bluestem	7%
Sporobolus cryptandrus	Sand dropseed	6%
Grasses Total		50%
Forbs		
Cassia wrightii	Partridge pea	2%
Gaillardia pulchella	Indian blanket	6%
Helianthus maximiliani	Maximillian sunflower	4%
Ratibida columnaris	Mexican hat	6%
Engelmannia pinnatifida	Engelmann daisy	2%
Forbs Total		20%
Woody		
Artemesia ludoviciana	Mexican sagewort	5%
Atriplex canescens	Four-wing saltbush	7%
Acacia greggii	Catclaw acacia	5%
Chrysothamnus nauseosus	Rubber rabbitbrush	6%
Rhus aromatica	Skunkbush	7%
Woody Total		30%
Seed Mix Total		100%
Note: If seed for a selected species is not available at the time of planting, a reasonably equivalent species from the same genus may be substituted.		

reduce erosion and runoff. Native hay mulch will be applied at the rate of approximately 2 tons per acre. Mulch may be spread by hand or mechanical methods. Mulch materials will be distributed evenly and uniformly over the site to be treated.

Mulches will be crimped, netted or tacked using standard accepted practices to realize their maximum effectiveness. The type of surface roughening, seeding operations and mulching methods including anchoring practices to be used for revegetating an area will determine the sequence of operations. Generally, operations will be performed in an order that maximizes the effectiveness of all of the combined treatments. Normally, seeding will be performed after surface roughening and before mulching operations. There are several exceptions to this commonly used sequence. One occurs when land imprinting is used with drill or broadcast seeding methods. In this case seeding, mulching and then land imprinting is performed.

Cotton burs are available locally and have been used as a suitable mulch material. Depending upon their availability at the time the upland area is restored, they may be used in place of native hay. When burs are used they will be applied at a rate that results in approximately 80% of the soil surface being covered. It will not be necessary to crimp cotton burs.

<u>Vegetation Community Restoration – Transplanting.</u> After seeding and mulching is completed, woody and succulent species will be transplanted on the restoration site. Many native plant species with potential use in restoration were observed at the site during this evaluation (Table 6.3.4). Additionally, conversations with the local NRCS range conservationist served to select potential restoration species. Species have been included in the proposed restoration species list based upon their presence and performance in Rough Breaks range sites on adjacent upland areas and upon the goal of increasing biodiversity on the site. Scrub-shrub vegetation community plant species growing in and around the restoration area were evaluated for their potential for seed harvest or other forms of propagation for restoration seeding or transplanting purposes.

Transplants will be placed in a mosaic pattern on approximately 7 acres, as shown on Figure 6.3.3. Transplants will be spaced randomly between 5 and 13 feet apart at a density of approximately 500 stems per acre. Species that benefit from fertilization, transplant mats, or protector sleeves will be treated accordingly. Potential species to be transplanted include catclaw acacia, redbud, Texas red buckeye, havard oak, redberry juniper, yucca, eastern cottonwood, and black willow. Species transplanted will be randomly selected and placed within these designated planting areas, with two exceptions. Eastern cottonwood and black

Legend

- Uplands Conservation
- Tree & Shrub Transplant Areas
- Seeded Areas
- Riparian Restoration

N

400 0 400 Feet

ENTRIX

Figure 6.3.3

Uplands Planting Plan
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 6/18/01

Table 6.3.4 – Potential Upland Restoration Plant Species

SPECIES	COMMON NAME
Grass/Grass-like Species	
Andropogon gerardii	Big bluestem
Andropogon saccharoides	Silver bluestem
Aristida fendleriana	Fendler three-awn
Aristida purpurea	Purple three-awn
Bouteloua curtipendula	Sideoats grama
Bouteloua gracilis	Blue grama
Bouteloua hirsuta	Hairy grama
Bouteloua nigra	Black grama
Buchloe dactyloides	Buffalo grass
Hilaria belangeri	Curly mesquite
Panicum virgatum	Switchgrass
Schizachyrium scoparium	Little bluestem
Seteria macrostachya	Plains bristlegrass
Sorghastrum nutans	Indiangrass
Sporobolus cryptandrus	Sand dropseed
Tridens muticus	Slim tridens
Forb Species	
Cassia wrightii	Partridge pea
Engelmannia pinnatifida	Engelmann daisy
Gaillardia pinnatifida	Blanket flower
Gaillardia pulchella	Indian blanket
Helianthus maximiliani	Maximillian sunflower
Lupinus spp.	Lupine
Ratibida columnaris	Mexican hat
Sphaeralcea hastulata	Globe mallow
Shrub/Tree Species	
Acacia greggii	Catclaw acacia
Aesculus pavia	Texas red buckeye
Artemesia filifolia	Sand sagebrush
Artemesia ludoviciana	Louisiana sagewort
Atriplex canescens	Four-wing saltbush
Ceanothus americanus	Buckbush
Celtis reticulata	Hackberry
Chrysothamnus nauseosus	Rubber rabbitbrush
Juniperus pinchotii	Redberry juniper
Populus deltoides	Eastern cottonwood
Prosopsis glandulosa	Mesquite
Rhus aromatica	Skunkbush
Salix nigra	Black willow
Yucca rupicola	Yucca

willow cuttings will be planted only in the two wetter areas that exist in the upland area.

6.3.4 Timing of Activities

The restoration of the upland area will be completed in the second year of activities, as described below. Generally, soil preparation will begin in the fourth quarter of the first year and the seeding and transplanting of upland species will occur in the first quarter of the second year.

4th Quarter - First Year:
- Surface grading
- Herbicide application on areas dominated by undesirable herbaceous species
- Soil preparation and amendments in areas of concern
- Seedbed preparation
- Seeding of cover crop

1st Quarter - Second Year:
- Seeding of herbaceous species over the entire 25 acre project area
- Placement of mulch throughout the seeded area
- Planting of approximately 3,500 trees and shrubs over 7 acres of the uplands project area

6.4 Enhance Open Water Aquatic Habitat

The goal as stated in Section 6.0 is to enhance an existing freshwater aquatic habitat system. The objectives for this goal are:

- Increase the surface area and volume of an existing stock pond;
- Decrease sediment loading of the pond by minimizing erosion;
- Maximize the extent and duration of ponding; and
- Enhance emergent vegetation within the pond system.

6.4.1 Existing Conditions

An existing stock pond is located on the south side of the Colorado River, between the river and Business Interstate 20. The soil surrounding the stock pond is classified as Rough Broken Land, according to the Mitchell County Soil Survey. This soil type is characterized in this particular area by loose soil, washed down-slope by strong rains. This loose soil normally lies on top of weakly cemented and calcareous sandstone. In the upper slopes of the watershed there are rocky sandstone outcrops and boulders. Short and strong rains characterize this region, carving steep V-shape gullies and exposing clayey shale, sandstone, and caliche.

The stock pond was created approximately 30-40 years ago by constructing a berm across a drainage that historically entered the Colorado River. The existing pond contains approximately 1.6 acres of open water at high stage. The watershed area of the pond and adjacent drainage way is sparsely vegetated by scrub/shrub woody plants, forbs, and herbaceous grasses. The dominant woody vegetation includes mesquite, salt cedar, and red berry juniper. Black willow is also present in areas of the existing pond that are more frequently inundated with water. Emergent vegetation is localized at the fringes of the existing pond in areas of gradual slope.

Surface water at the pond site generally flows from Business Highway I-20 northeast towards the Colorado River. The watershed within the pond site can be divided into two sub-watersheds. One sub-watershed currently contributes run-off to the pond system. The second sub-watershed contains a large drainage way, formed by two smaller ones, that bypasses the stock pond just east of the existing pond (Figure 6.4.1). A spillway located in the southwest corner of the pond connects the existing stock pond to one of the smaller drainage ways. During high flow events, the spillway is designed to allow excess water to leave the pond and flow into the Colorado River. The spillway, due to its age, is currently starting to show wear in the form of bare, washed out areas. Two areas located at the southern bank of the existing pond are also showing signs of active erosion. The easily erodable soils, found within the watershed area, contribute large amounts of silt to the pond and river during strong storm events.

Since an approximate 4.6-inch storm event on March 22, 2000 that filled the existing pond to its maximum depth, pond water levels have been monitored on a weekly basis. Monitoring of water levels show an average loss of approximately 426,806 gallons of water per month when the pond is full. The data collected indicates that loss of water from the pond is due to both evaporation and infiltration. Using a weekly water budget model it is estimated that evaporation accounts for approximately 74% of the water loss and infiltration for approximately 26%.

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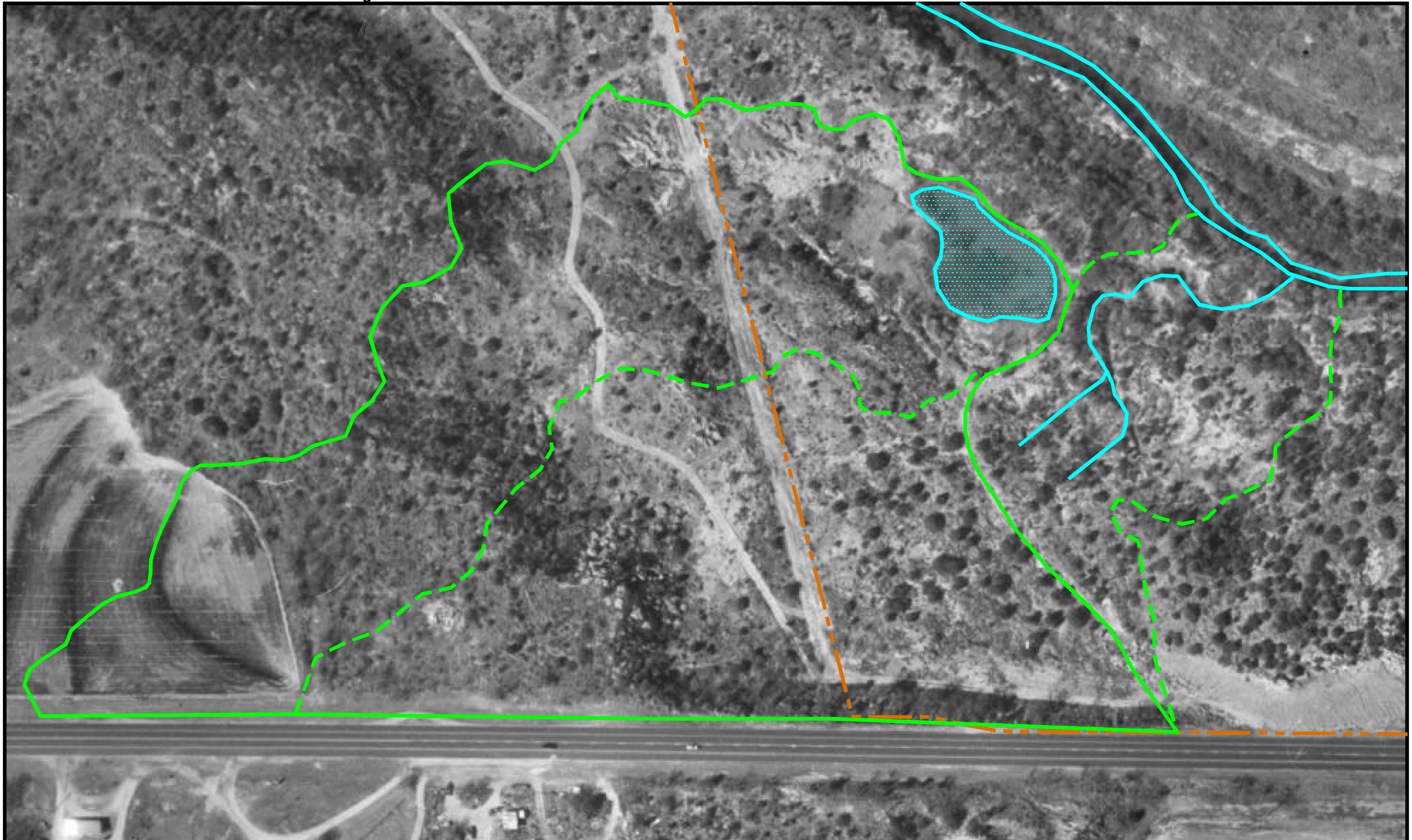


LEGEND:

- PROJECT PROPERTY BOUNDARY
- WATERSHED OF ENHANCED POND
- PRECONSTRUCTION SUB-WATERSHEDS

0 200
FEET
APPROX. SCALE

N

E N T R I X

Figure 6.4.1
Location of Pond and its Watershed
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 10/00

6.4.2 Planned Action

There are five priorities for open-water enhancement as proposed for this site: minimize existing and active erosion occurrences, enhance emergent vegetation, stabilize and improve existing spillway, increase contributing watershed, and minimize infiltration. Details for each item follows.

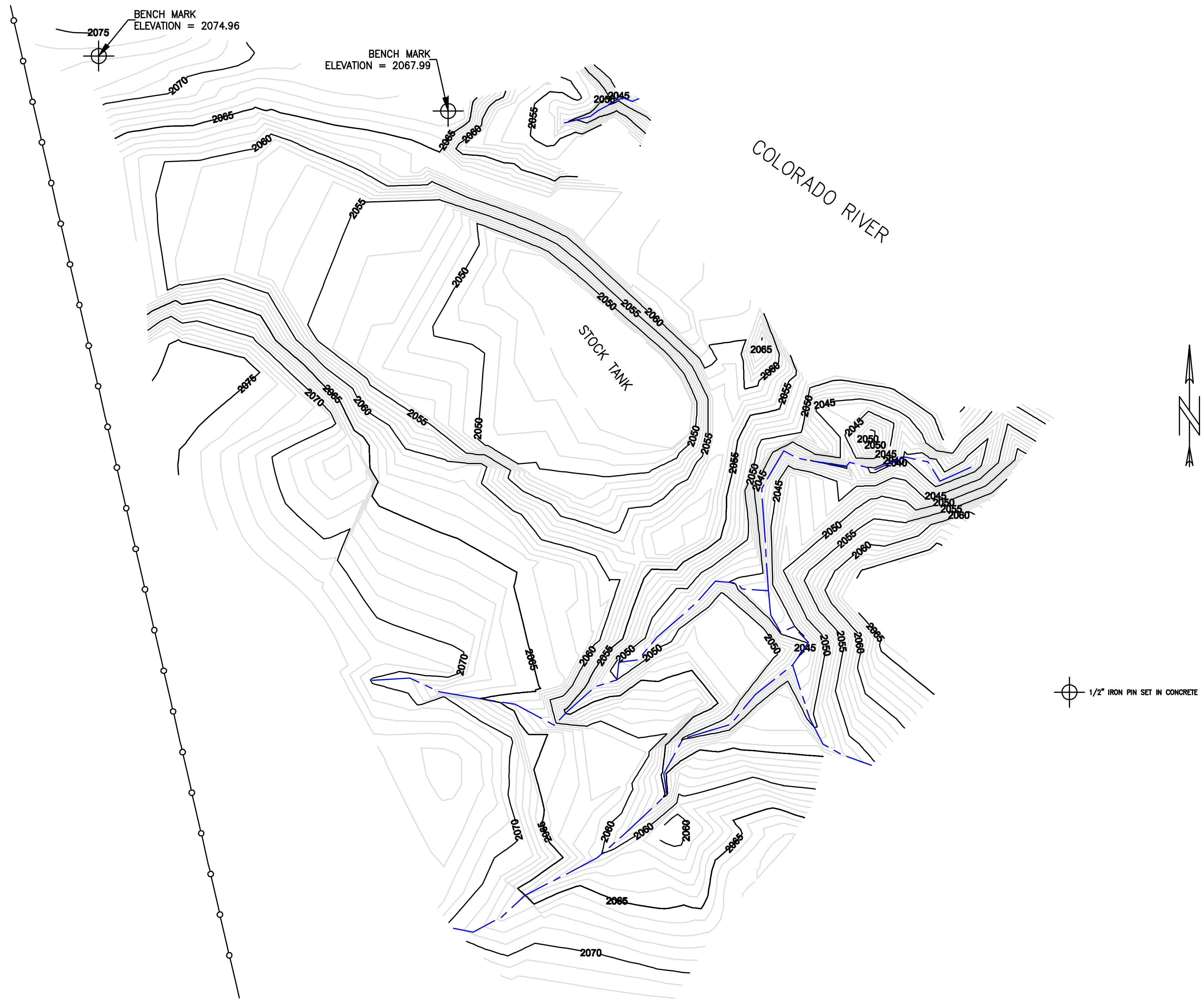
Minimize Existing and Active Erosion Occurrences. In order to stabilize areas surrounding the existing pond that are actively eroding, erosion control measures will be undertaken. Erosion control measures will serve to protect the stability of the banks and minimize siltation of the pond. The following erosion control measures are proposed:

- Re-grade existing pond banks to 2:1 slopes, in select areas as needed. Refer to Figures 6.4.2 and 6.4.3 showing the pre-construction and post-construction topography of the pond system area, respectively). Figure 6.4.4 shows a cross-section of the enhanced pond;
- Install erosion control blankets or jute netting for bank stabilization during plant establishment in localized areas (See Figure 6.4.5); and
- Establish vegetative cover along the banks of the pond to provide long-term slope protection.

Enhance Emergent Vegetation. In order to enhance existing emergent vegetation, the northwest corner of the pond will be re-graded to a 1% slope. Re-grading activities will provide approximately 0.5 acres of suitable substrate for emergent vegetation establishment. Details regarding the proposed actions for emergent vegetation establishment are included in Section 6.4.4.

Stabilize and Improve Existing Spillway. In order to prevent further deterioration of the spillway and extend the life of the pond, improvements will be made to increase the stability and structural integrity of the existing spillway. The improved spillway will be designed to sustain high water flows. The spillway will be graded and protected from erosion with the use of cellular confinement stabilization (Figure 6.4.6). Following the installation of the cellular confinement system, the area will be re-vegetated with a seed mixture containing native, perennial, warm-season sod-forming and bunch type grasses Figure 6.4.7 shows details of the spillway cross section.

Increase Contributing Watershed. In order to increase the contributing watershed, two drainage ways that currently bypass the existing pond will be channeled into the pond by the construction of a drainage swale. The drainage swale will run from south to north towards the existing pond, diverting the current flow of the two drainage ways. The proposed modification to the watershed area is shown in



LEGEND:

— 2050 — - EXISTING CONTOURS

0 100
FEET
APPROX. SCALE

E N T R I X

Figure 6.4.2
Pre-Construction Contour Map
Col-Tex Restoration
Colorado City, Texas

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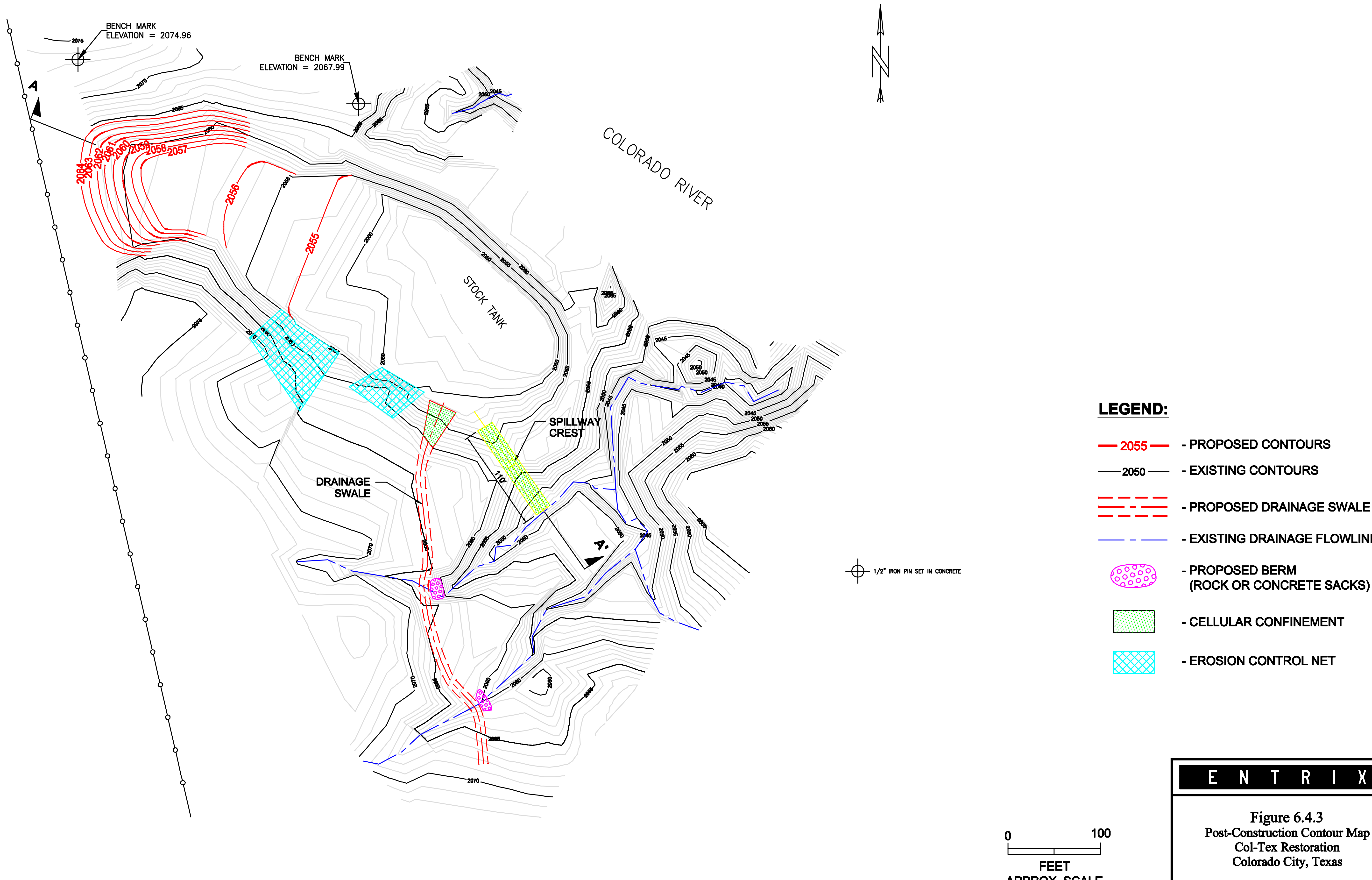

ENTRIX

Figure 6.4.3
Post-Construction Contour Map
Col-Tex Restoration
Colorado City, Texas

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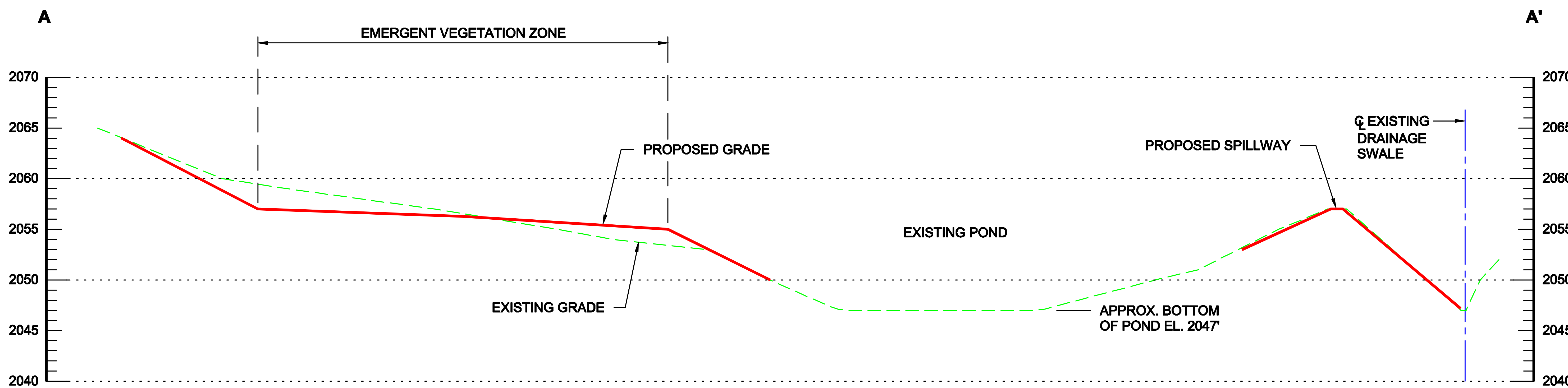

ENTRIX

Figure 6.4.4
Pond Cross-Section A-A'
Col-Tex Restoration
Colorado City, Texas

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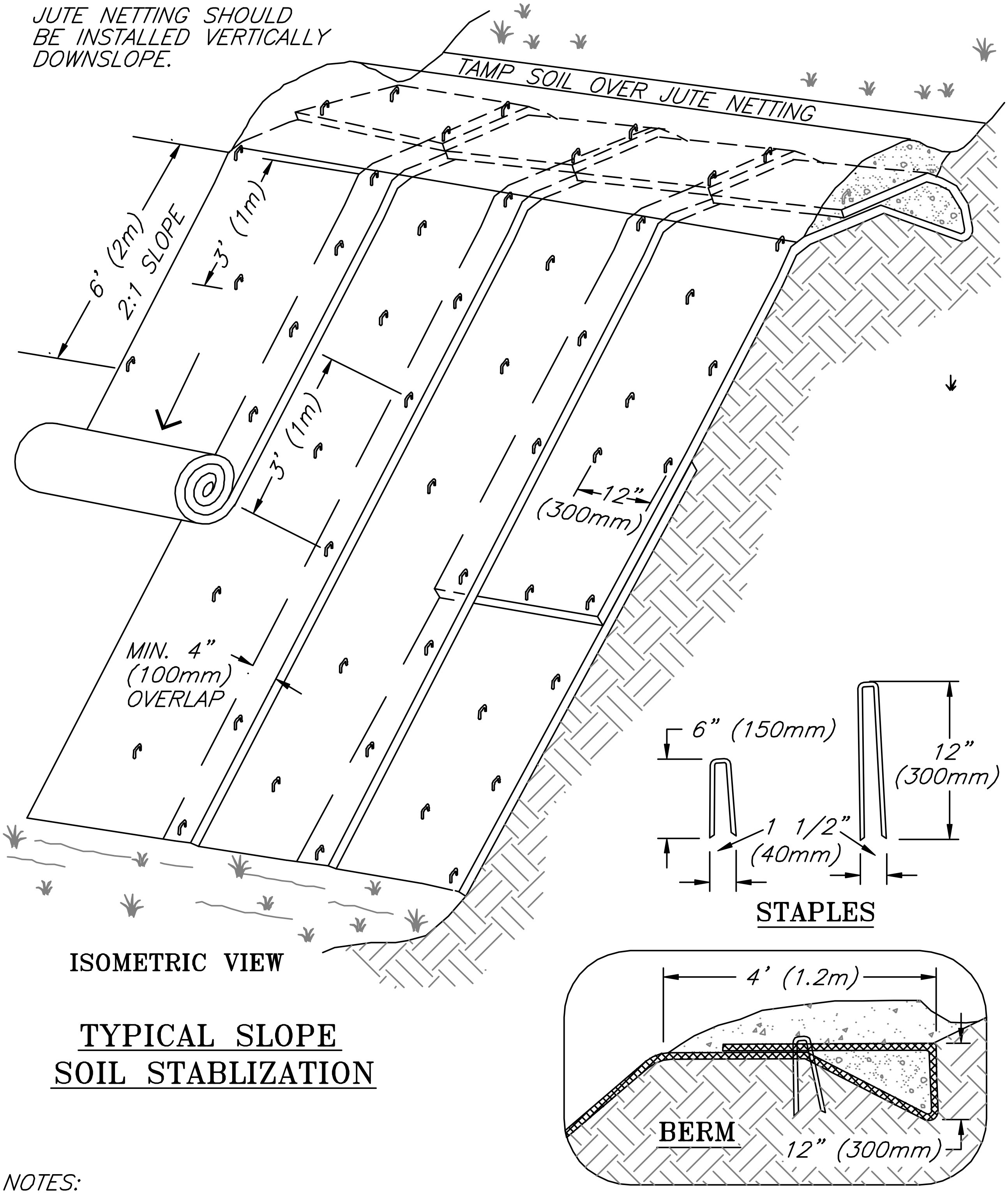

TYPICAL SLOPE SOIL STABLIZATION

NOT TO SCALE

NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. JUTE NETTING SHALL HAVE GOOD SOIL CONTACT.

2. APPLY PERMANENT SEEDING BEFORE PLACING JUTE NETTING.

3. LAY JUTE NETTING LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

ENTRIX

Figure 6.4.5
Erosion and Turf Reinforcement Netting Slope Installation
Col-Tex Restoration
Colorado City, Texas

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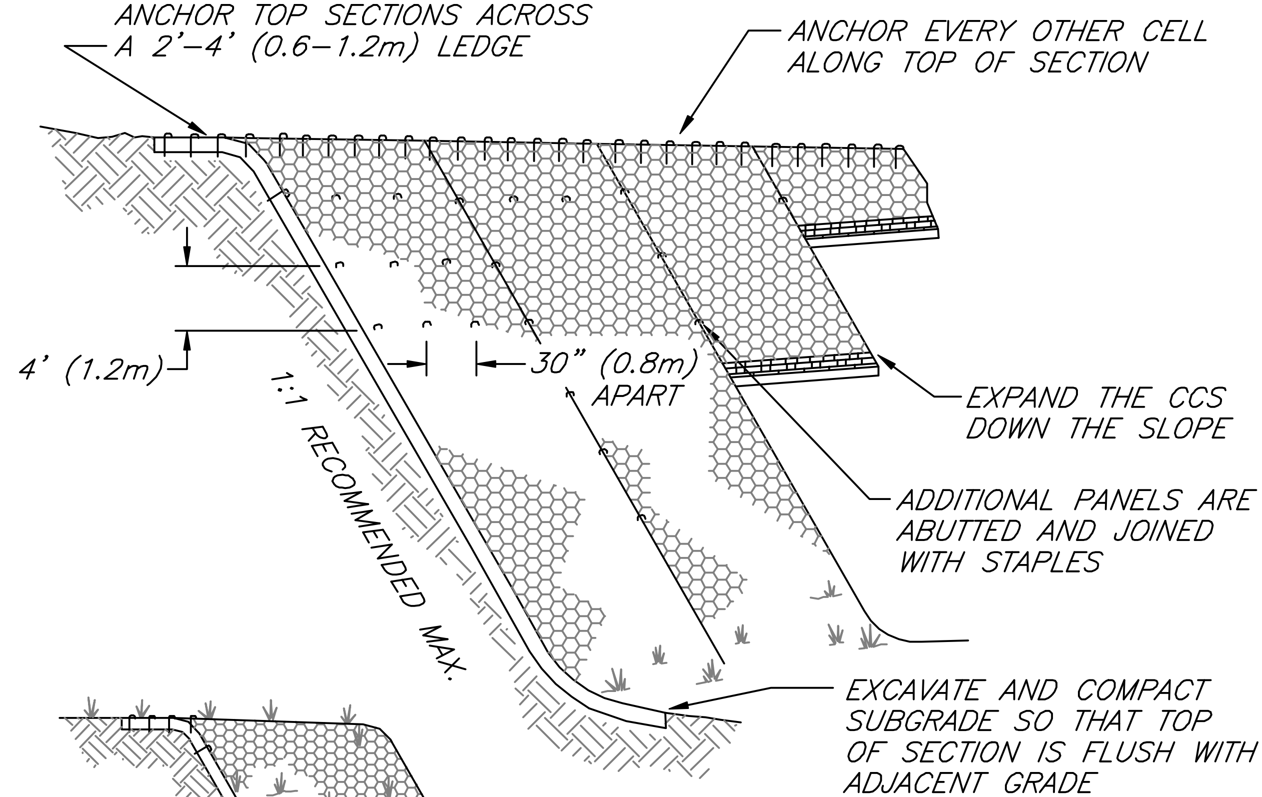
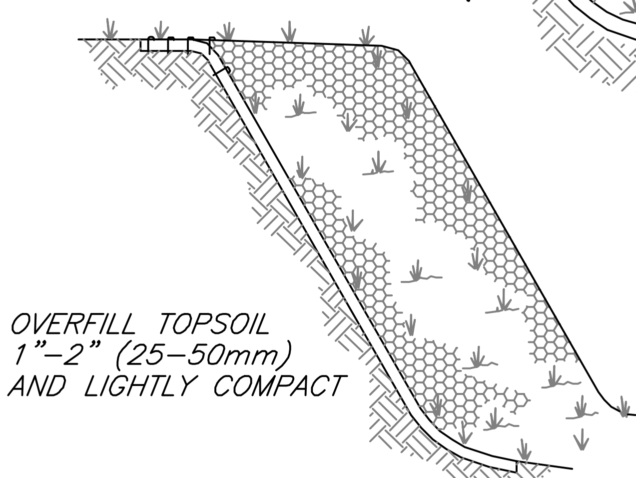
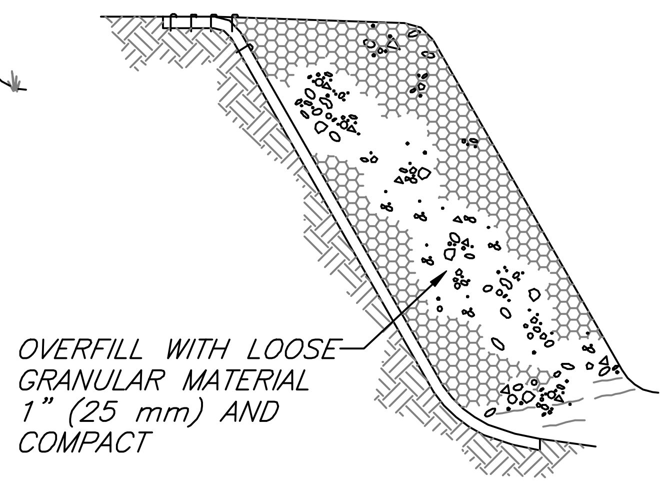




CCS INFILLED WITH TOPSOIL AND VEGETATED WITH GRASS

CCS INFILLED WITH AGGREGATE



NOTES:
1. SURFACE OF SLOPE SHALL BE LEVELED WITH GULLIES FILLED AND WELL COMPACTED.
2. SHAPE AND COMPACT SUBGRADE SURFACES TO DESIGN ELEVATIONS AND GRADES.
3. THE CELLS SHALL BE ANCHORED SECURELY TO PREVENT DISPLACEMENT AND DEFORMATION OF PANELS WHEN BACKFILLING.
4. INFILL FROM CREST OF THE SLOPE TO TOE TO PREVENT DISPLACEMENT. LIMIT DROP HEIGHT TO 3' (1m).

NOT TO SCALE

ENTRIX

Figure 6.4.6
Cellular Confinement System for Slope Stabilization
Col-Tex Restoration
Colorado City, Texas

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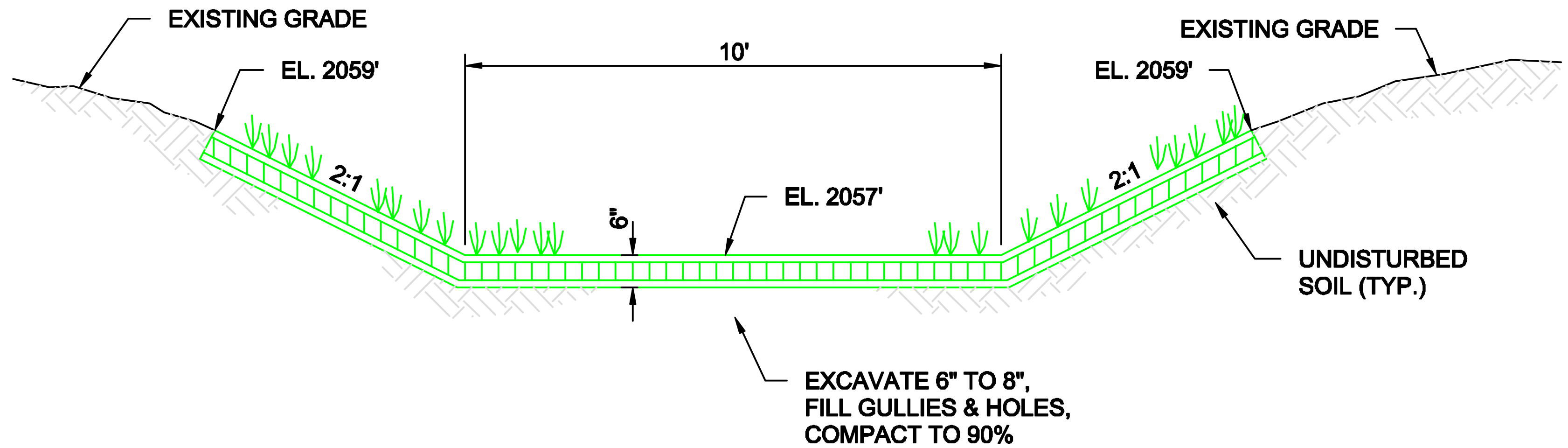

SPILLWAY SECTION

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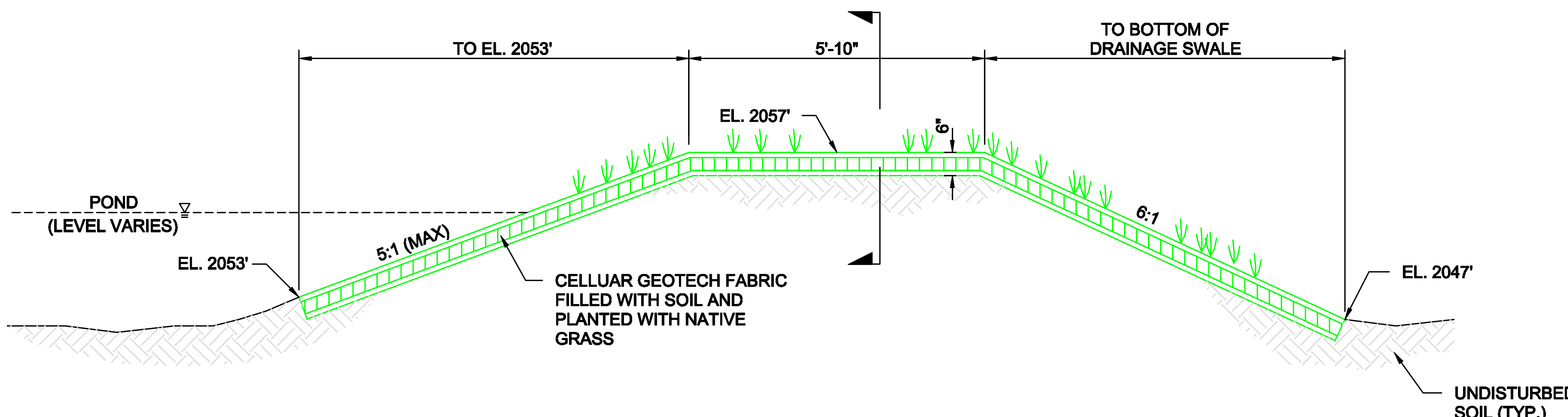

SPILLWAY LONGITUDINAL SECTION

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Figure 6.4.7
Spillway Details
Col-Tex Restoration
Colorado City, Texas

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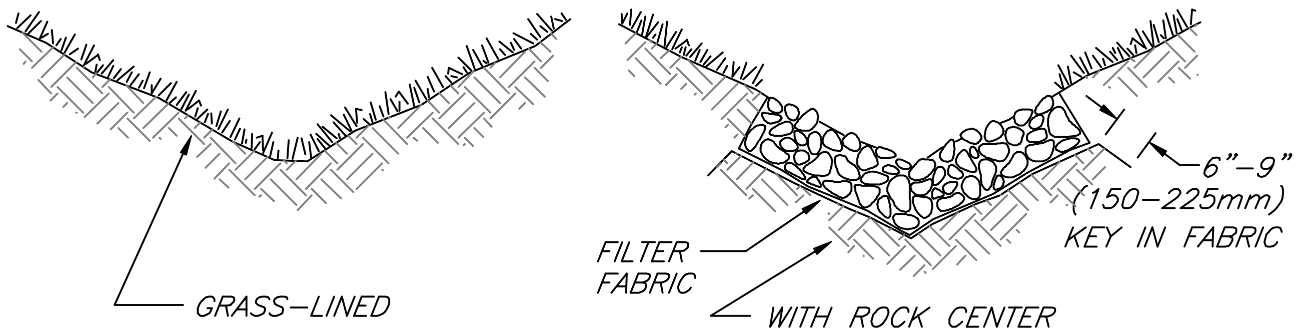
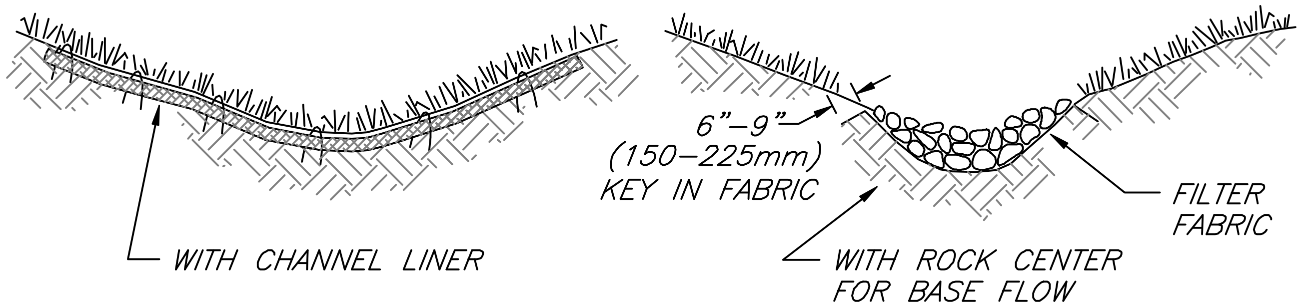
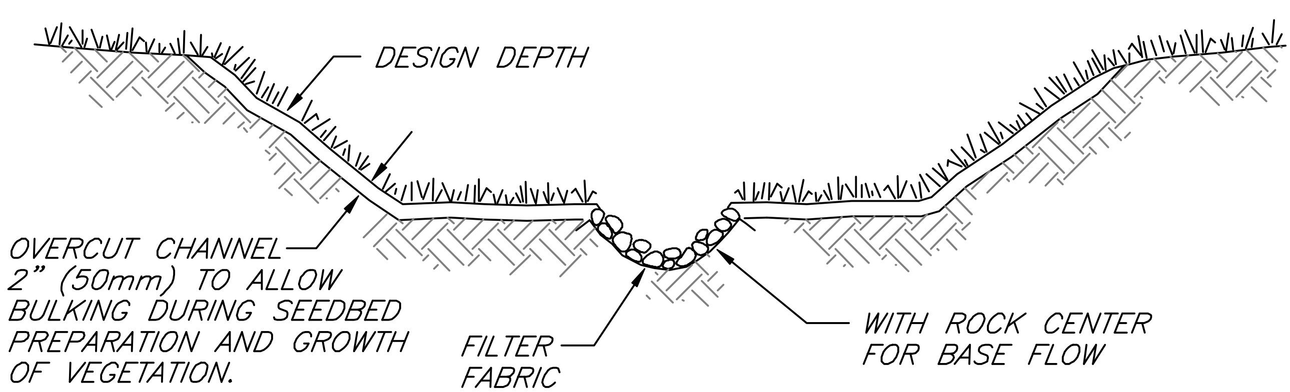


TYPICAL V–SHAPED DRAINAGE WAY
CROSS–SECTION



TYPICAL PARABOLIC DRAINAGE WAY
CROSS–SECTION



TYPICAL TRAPEZOIDAL DRAINAGE WAY
CROSS–SECTION

NOT TO SCALE

E N T R I X

Figure 6.4.8
Grass-Lined Drainage Way
Typical Cross Sections
Col-Tex Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 10/00

Figure 6.4.1. The location of the proposed drainage swale is depicted in Figure 6.4.3. The drainage swale will be constructed based upon the design methods illustrated in Figure 6.4.8. The design method selected will be location-specific and will depend upon the type of substrate the drainage swale crosses.

Minimize Infiltration. To decrease infiltration losses from the pond, the following measures are proposed:

- Pump water from the pond to create a dry workspace;
- Excavate accumulated silt from the bottom;
- Remove all debris within the extent of the pond; and
- Re-compact and add clay or an engineer-approved alternative at the base of the pond to seal areas of potential infiltration.

6.4.3 Water Budget

A water budget is a model that accounts for the relative inflows and outflows of water to a system. The depth of water in the pond and duration of water in the system can be predicted from the results of the water budget. The model used here is based on monthly precipitation, and estimates of evapotranspiration and groundwater outflow. All units relate to a depth of water over the design pond system. One of the most widely used formulas for modeling water inputs, outputs, and storage is from Pierce, 1992:

$$P + SWI + GWI = ET + SWO + GWO + -S$$

Where:
P = Precipitation
SWI = Surface water inflow
GWI = Groundwater inflow (assumed to be zero)
ET = Evapotranspiration (use pan evaporation data)
SWO = Surface water outflow (not applicable)
GWO = Groundwater outflow (assumed to be zero or 0.1 in/month)
–S = Change in storage (not applicable, no base level is maintained)

Water levels expected during average water years, based on the results of the water budget models for the first and second years, are shown in Figures 6.4.9 and 6.4.10, respectively. Figures 6.4.11 and 6.4.12 depict the expected surface acreage for the enhanced pond for the first and second average water years, respectively. A discussion of the variables in the above model follows.

Precipitation. The precipitation in this area is characterized by episodic, infrequent rainfall events, resulting in rapid runoff. Data from the Colorado City

Figure 6.4.9 – Average Monthly Water Levels of Enhanced Pond, Year 1

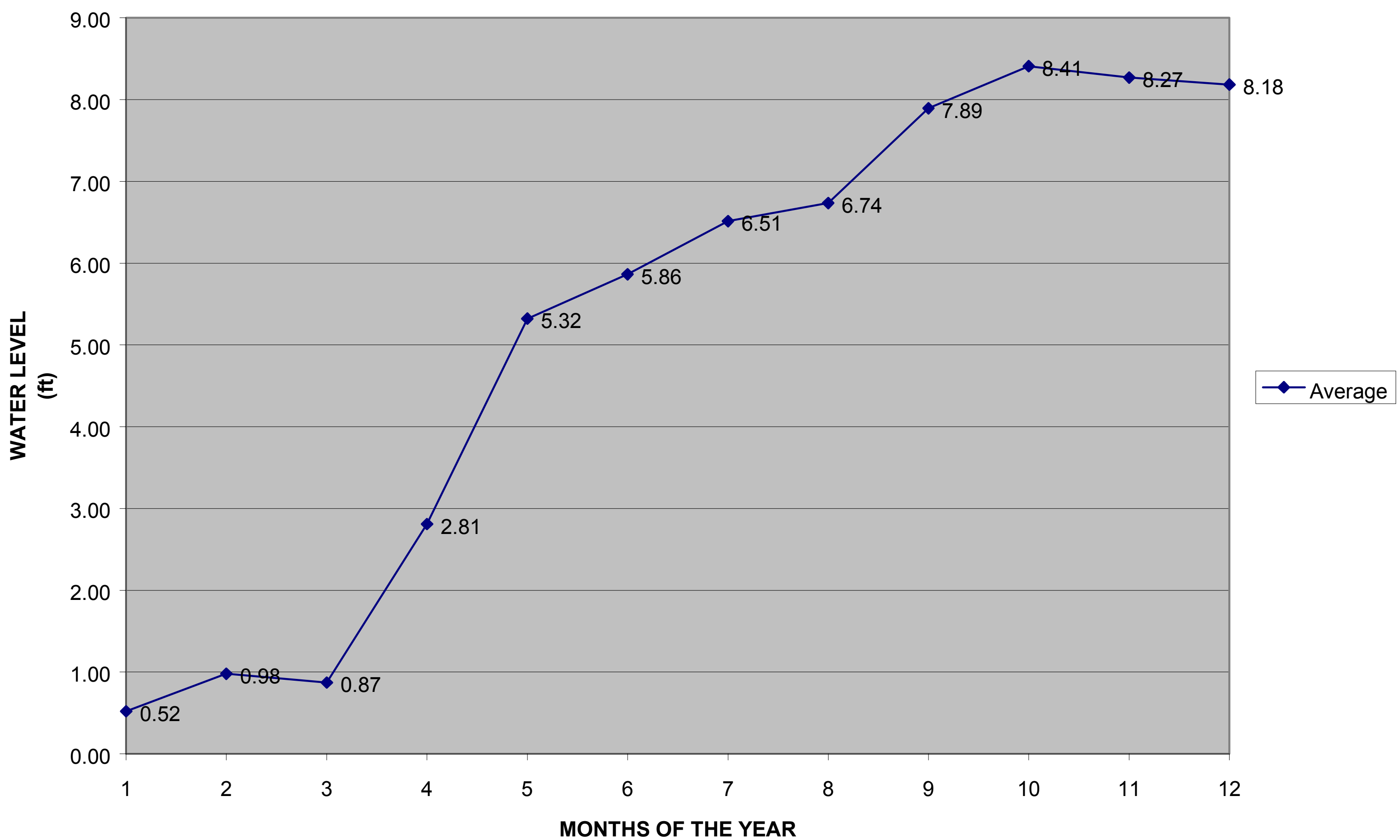


Figure 6.4.10 – Average Monthly Water Level for Enhanced Pond, Year 2

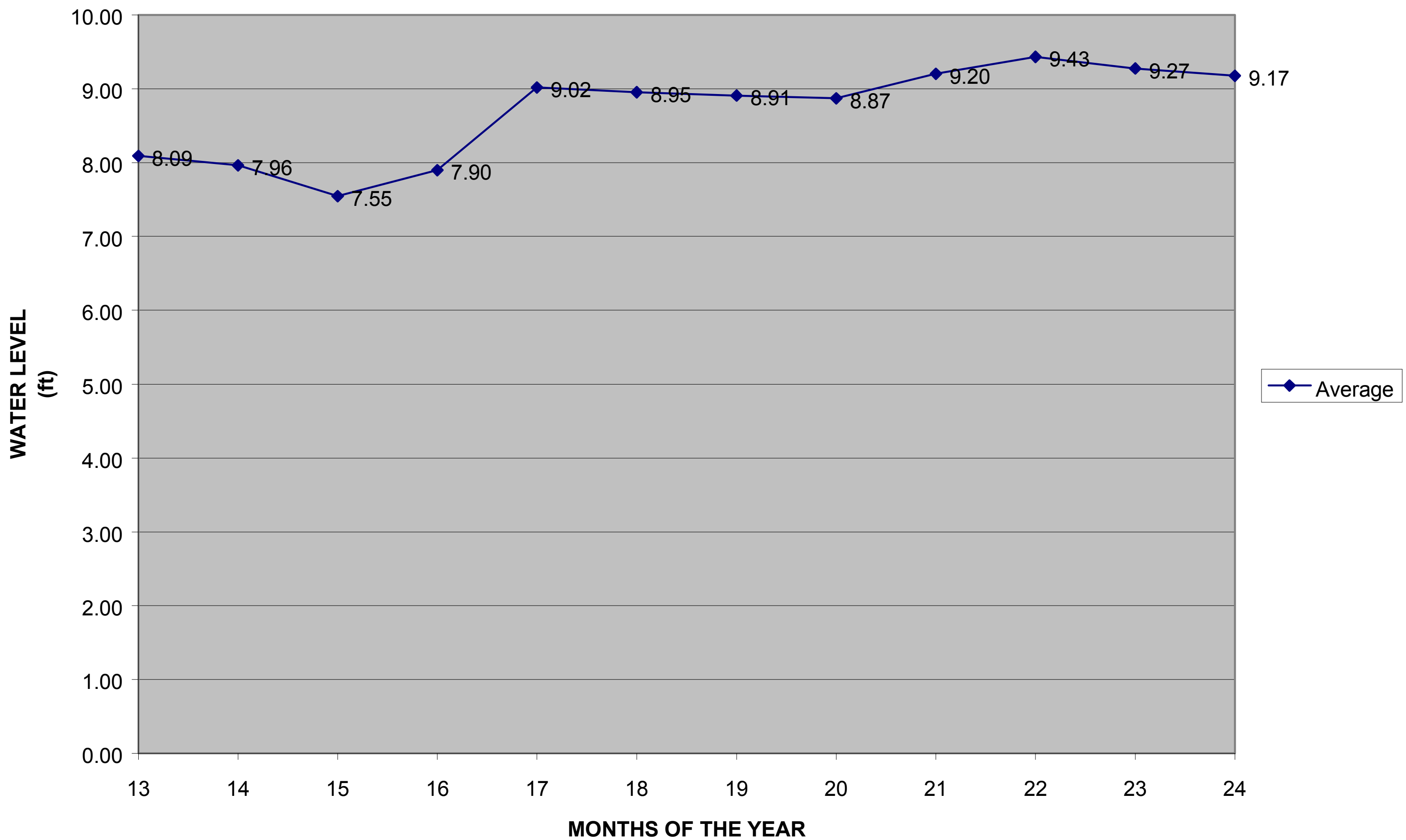


Figure 6.4.11 – Average Monthly Surface Water Acreage for Enhanced Pond, Year 1

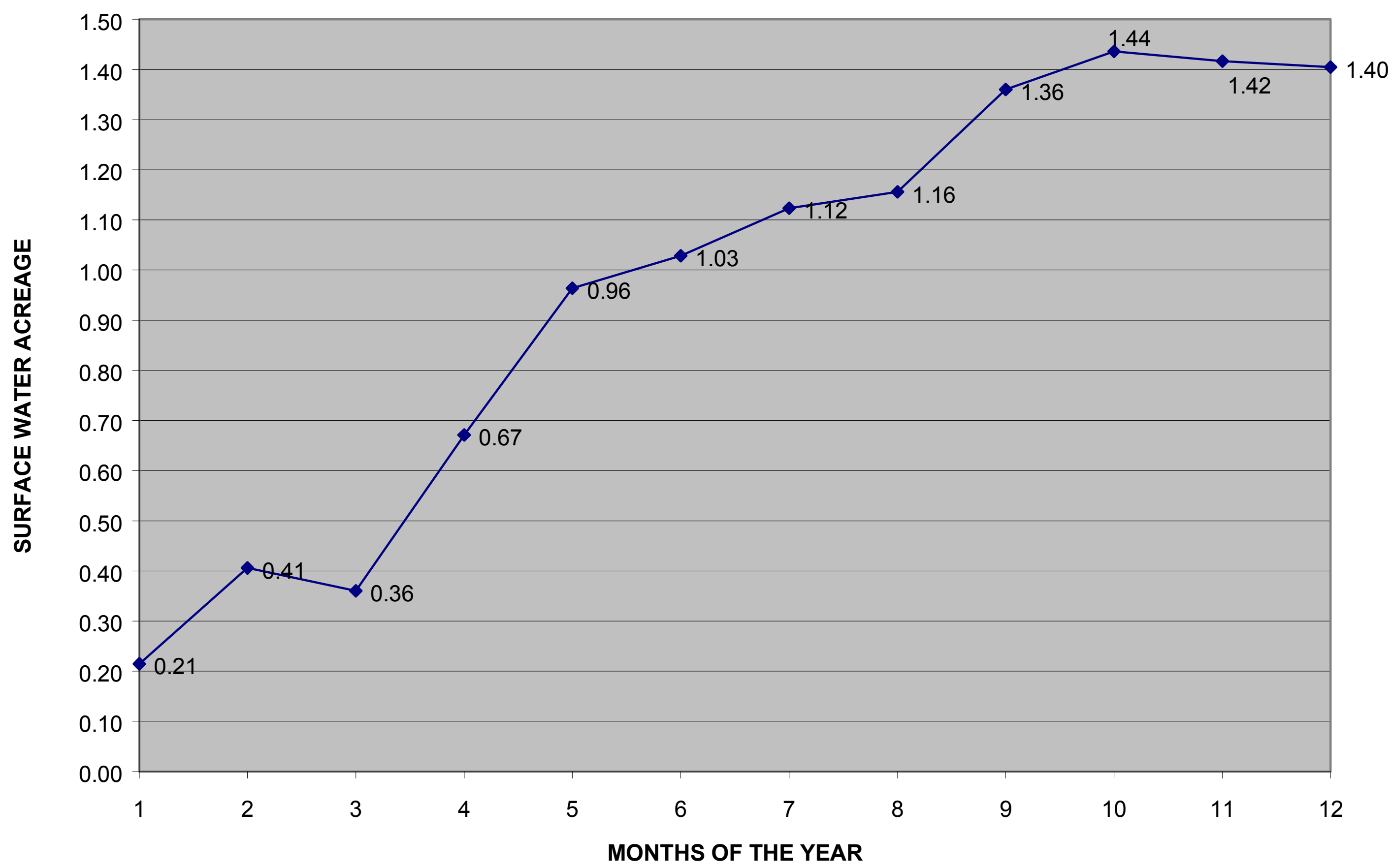
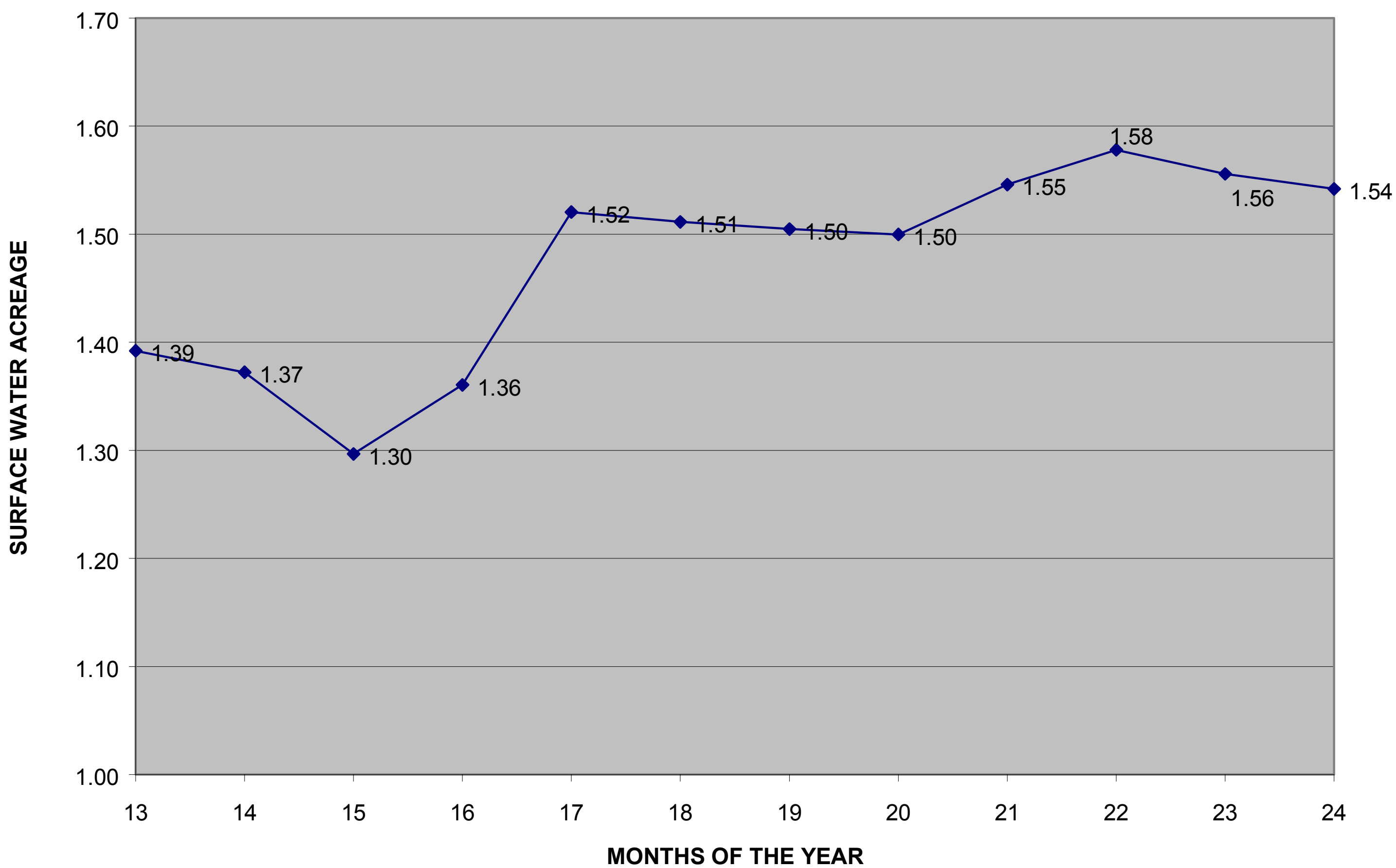


Figure 6.4.12 – Average Monthly Surface Water Acreage for Enhanced Pond, Year 2



meteorological station indicates that mean annual precipitation over the 72 years of record (including years from 1898 to 1995) is 21.13 inches. Total precipitation varies from 12 inches in dry years to 35 inches in wet years.

Surface Water Inflow. As previously indicated, surface water at the pond site generally flows from Business Interstate 20 northeast toward the Colorado River. After construction of the drainage swale, an additional 13 acres of watershed area will be redirected to the enhanced pond. The total watershed area contributing to the enhanced pond after construction will therefore be approximately 22 acres. based on the results of the water budget, the drainage swale should provide enough additional runoff area to provide 1.5 acres of surface water under average conditions.

The total volume of surface water that would enter the pond system from its watershed, referred to as surface water inflow (SWI), is determined from the product of watershed area and predicted runoff depth. Runoff depths have been predicted by using the curve number method described in USDA Agriculture Handbook 590. The runoff depth is based on two factors: monthly precipitation and the runoff curve number (CN). The CN is determined based on soil type. The watershed area of the pond system can be classified as (FAIR) DESERT SHRUB having two types of soil, C and D, within the sub-watersheds. Based on these soil types a weighted Curve Number (CN) of 84 was determined. Using this curve number and monthly precipitation data, the runoff depth is determined for each month. The SWI is therefore calculated for each month by multiplying the resultant runoff depth and the sub-watershed area.

Groundwater Outflow. Groundwater outflow, or infiltration, is determined by the permeability of the soil. In order to determine the permeability of the type of soil in and around the existing pond, soil samples were sent to a geotechnical laboratory for analyses. The results indicated that the soils are composed of red, brown sandy, silty clay with a permeability of about 4×10^{-6} cm/sec. This permeability equates to a loss of approximately 1-inch of water due to infiltration per month, but it does not account for infiltration caused by trees, plant roots or potential small fractures in the structure.

For design purposes of the pond, it will be assumed that groundwater outflow, or infiltration, can be controlled by compaction of the subsoil or by providing a layer of impervious material at the base of the pond to decrease the permeability to 10^{-7} centimeter per second (cm/s) or less. A permeability of 10^{-7} cm/s equates to a loss of approximately 0.1 inches of water due to infiltration per month.

Evaporation. Monthly average pan evaporation rates were used in the water budget to determine the losses of surface water from the pond. The evaporation rates were gathered from a historic record of 11 years (1957 – 1962) collected in Colorado City and reported by the National Climatological Data Center. Total annual evaporation is 89.43 inches and monthly averages range from 2.82 inches in January to 12.44 inches in July. Monthly average evaporation was used in the water budget.

Water Budget Results. The water budget was run over a two-year period, assuming average conditions. For purposes of modeling, existing topographic relief was used. Depth of ponding in the enhanced pond was modeled using actual average precipitation and evaporation data.

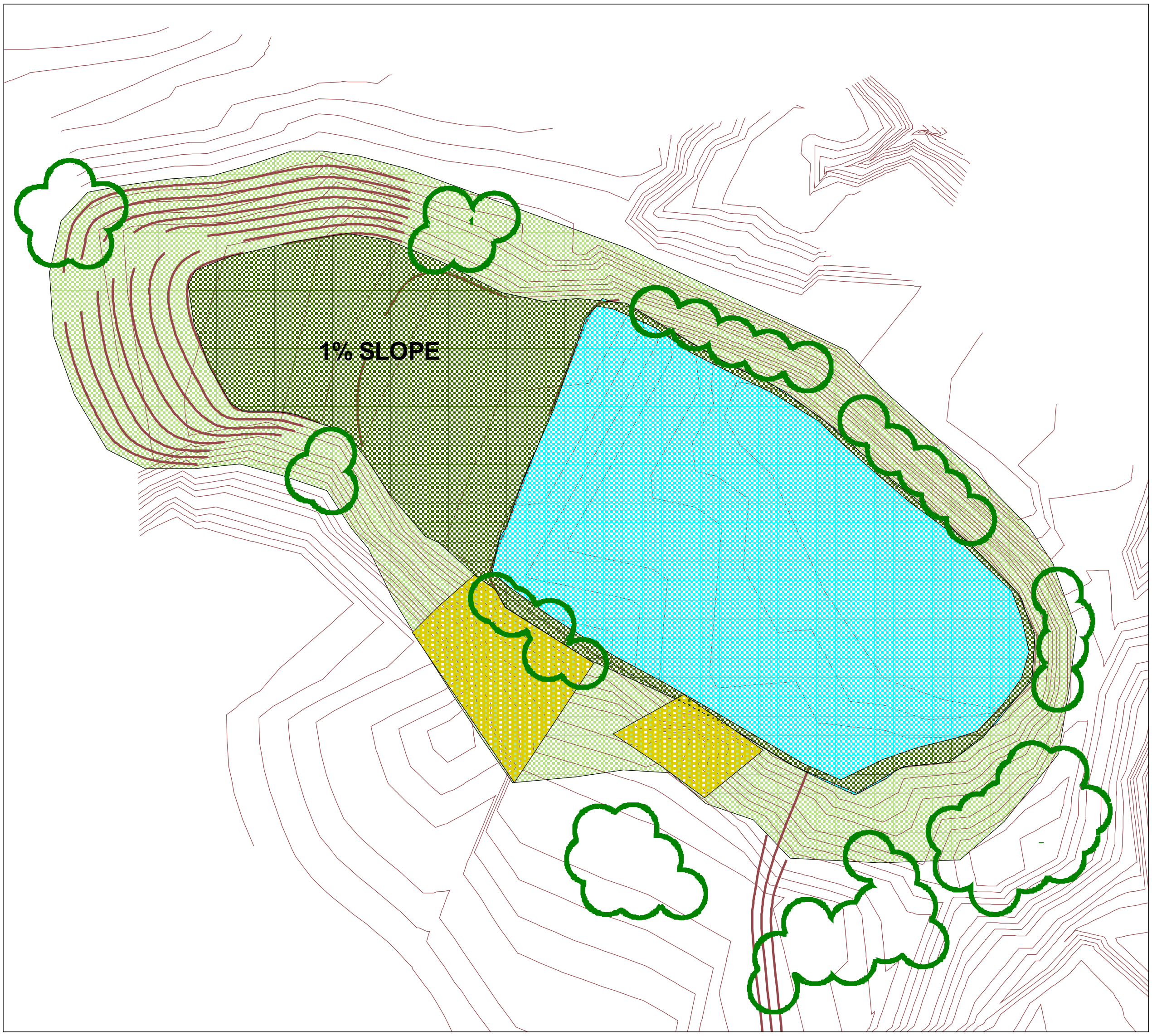
The results of the average year water budget are plotted for the first year in Figures 6.4.9 (based upon water levels) and 6.4.11 (based upon surface acreage). The water budget model begins with the assumption that the pond is dry in January due to lack of rain and effects of evaporation. Based on average precipitation and evaporation, during the months of January, February and March ponding is expected to be minimal. By May of the first year, the pond depth should increase to approximately 2.8 ft, which correlates to 0.67 acres of open water.

According to the water budget results, the water levels should increase throughout the remainder of Year 1. If climatic conditions continue to be average in the following year, the existing pond would hold water throughout the year, maintaining a water level between 7 and 10 feet, which equates to between 1.3 and 1.6 acres of open water. The results of the average year water budget for the second year is shown in Figures 6.4.10 (based upon water levels) and 6.4.12 (based upon surface acreage).

6.4.4 Planting Plan

Vegetation will be planted around the margins of the pond. Re-vegetation will be conducted in these areas to enhance wildlife habitat value and to provide erosion control. Re-vegetation activities will include a combination of seeding with native seed mixtures, planting of willow and cottonwood cuttings, and natural colonization, as described below. In addition, salt cedars within the pond planting area will be removed according to the procedures outlined in Section 6.2.3 of the riparian habitat restoration.

Vegetative Buffer Zone. A vegetative buffer zone will be created around the pond. The vegetative buffer zone will consist of three distinct plant communities: 1) herbaceous vegetation consisting of native, warm-season grasses and forbs, 2) native trees consisting of black willow, eastern cottonwood, mesquite, and red berry juniper, and 3) emergent wetland vegetation (Figure 6.4.13).



N

200 0 200 Feet

Legend

- Contour Lines (1 ft intervals)
- Pond
- Seeded Grasses
- Areas Seeded for Erosion Control
- Potenial Emergent Vegetation
- Existing and Potential Tree Clusters

ENTRIX

Figure 6.4.13

Pond Planting
Col-Tex Restoration
Colorado City, Texas

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The riparian fringe surrounding the pond will be vegetated with herbaceous species as needed for erosion control purposes. Unrooted cuttings of black willow and eastern cottonwood will be planted at the edges of the pond in areas where additional bank stabilization is needed. Emergent wetland vegetation is expected to colonize the northwest corner of the pond where the slope will be re-graded to 1%. To a lesser extent, colonization should also occur along the pond margins where the slope is gradual enough to provide suitable substrate. Taking into account both the area to be regraded and pond margins where suitable substrate exists, approximately 0.6 acres of suitable substrate for emergent vegetation establishment will surround the enhanced pond.

Various techniques that will be used to establish native vegetation at the pond are outlined below. The buffer zone will be seeded with a mixture containing native, warm-season, perennial bunch grasses and forbs. Species which are likely to be contained in the seed mixture include: little bluestem (*Schizachyrium scoparius*), switchgrass (*Panicum virgatum*), indiangrass (*Sorghastrum nutans*), sand dropseed (*Sporobolus cryptandrus*), sideoats grama (*Bouteloua curtipendula*), alkali sacaton (*Sporolobus airoides*), bitter sneezeweed, lemon mint, camphorweed, goldenrod, ironweed, three-awn, sunflower, purpletop, wild four-o'clock, and linaria. The mixture will be seeded in early spring (March) once soil temperatures reach 55-65^{o} F. Seed will be broadcast or drilled into a prepared, weed-free seedbed and then raked or lightly tilled to incorporate seed to a depth of ¼ inch. The seedbed will then be rolled or packed to ensure good seed-soil contact. The area will be mulched with straw or cotton burs following seeding.

Establishment of wetland vegetation in the pond system will initially be allowed to occur through natural colonization. In addition, natural colonization of woody species, such as black willow and hackberry/sugarberry is anticipated based upon the existing vegetation. It is expected that revegetation in these areas will take advantage of the enhanced water source and moisture gradient surrounding the ponds to introduce additional native plant species and ultimately increase the diversity of plant communities present within the local landscape. In the event that natural colonization does not occur, efforts to assist development of emergent wetland vegetation may be necessary. Options for supplementing wetland vegetation in the pond system include transplanting suitable plant material harvested from the Colorado River, planting containerized seedlings from a commercial source, and/or seeding wetland species from a local source. Specific timing with regard to supplemental efforts to establish emergent vegetation is discussed in Section 7.2.3.

<u>Vegetative Stabilization & Erosion Control</u>. As well as providing a buffer zone for wildlife habitat enhancement, vegetation will be used to provide soil stabilization and erosion control on the newly graded slopes.

Following final grading, designated areas (see Figure 6.4.3) will be seeded with a seed mixture containing native, perennial, warm-season sod-forming and bunch type grasses. The seed mixture will consist of 50% buffalograss (*Buchloe dactyloides*), 25% sideoats grama, and 25% alkali sacaton. Per NRCS recommendations, seeding rates will be 4.0 #/ac., 1.125 #/ac., and 0.25 #/ac., respectively. In late winter to early spring after the last frost, the mixture will be planted by broadcasting it onto a prepared seedbed and incorporating it into the soil to a depth of ½ - ¾ inches. Immediately afterwards, the seeded area will be covered with jute matting or other similar erosion control fabric to provide immediate erosion protection prior to vegetation establishment. The erosion control matting will eventually biodegrade.

Buffalograss, the main component of the mixture, is a drought-tolerant, sod-forming turfgrass species, which spreads by seed and vigorous surface runners. As such, it may out-compete the other species in the seed mix, forming a monoculture. Establishing a monoculture is acceptable since buffalograss is best suited to erosion control. The other bunchgrass species are also suited to erosion control applications, but to a lesser degree. These species have been included in the seed mix to increase chances of successful vegetation establishment given the range of environmental conditions that exist at the planting site.

6.4.5 Timing of Activities

The construction of the pond system will commence in the first year of restoration activities. Following the formulation of detailed design specifications, the proposed pond will be constructed and modifications to the existing pond will be done. It is anticipated that construction will begin in the third quarter of the first year of restoration activities. Seeding and revegetation activities will be done during the first quarter of the second year.

6.5 Provide Wildlife Water Source

The goal as stated in Section 6.0 is provide a sustained source of water for wildlife use. The objectives for this goal are:

- Install a water catchment and access trough;
- Design the system to be used by large and small mammals and birds;
- Minimize maintenance requirements for the system;
- Place the wildlife water catchment in a location that will maximize its potential use.

6.5.1 Background

A wildlife water catchment consists of an apron for collecting precipitation, a tank to store it in, and a drinking trough that provides access to the water by different-sized wildlife species (BLM, 1997). Original designs were meant to supply water for gallinaceous birds such as quail, doves, partridge, etc. and were known as gallinaceous guzzlers (Glading, 1947). Later, guzzlers were installed in the southwest to provide water for bighorn sheep and other large mammals. Based on the Biological Inventory Evaluation (BIE) results from 1996-1997, large mammals are found in the project site area that will benefit from a guzzler designed to be accessible by large mammals, such as deer.

6.5.2 Planned Action

The proposed guzzler will be an aboveground 2,250-gallon tank constructed with an inverted umbrella lid. The tank will fill a separate ground-level drinking trough through a float valve. Alternately, if the site permits, the drinker will be self-leveling. A picture of the inverted umbrella tank and an installed drinking trough is shown in Figure 6.5.1. A diagram of the tank and drinking trough construction is shown in Figure 6.5.2. As shown in Figure 6.5.1, the drinking trough will be buried in the ground to reveal the water source and ramp to the water at ground level. The tank will also be buried to moderate the temperature of the water and protect the piping.

The wings constructed around the tank for the catchment are 16 feet in diameter. The tank will fill after 18 inches of rainfall. The average annual total rainfall for the Colorado City area is 21 inches.

The needs of target species are important considerations in the planning of a guzzler location. General guidelines for optimum spacing of water sources for select species found at the Col-Tex site and in the project area are summarized below (Payne and Bryant, 1998):

Species	Range of movements relative to water source	Water Development Spacing
Bobwhite quail	0.25 to .75 mi.	1.0 miles or less
White-tailed deer	1.0 to 1.8 mi; associated with riparian habitats	1.0 to 2.0 miles

The quality of the available water sources is also an issue in planning the location of guzzlers. While water quality standards for upland wildlife are not specifically

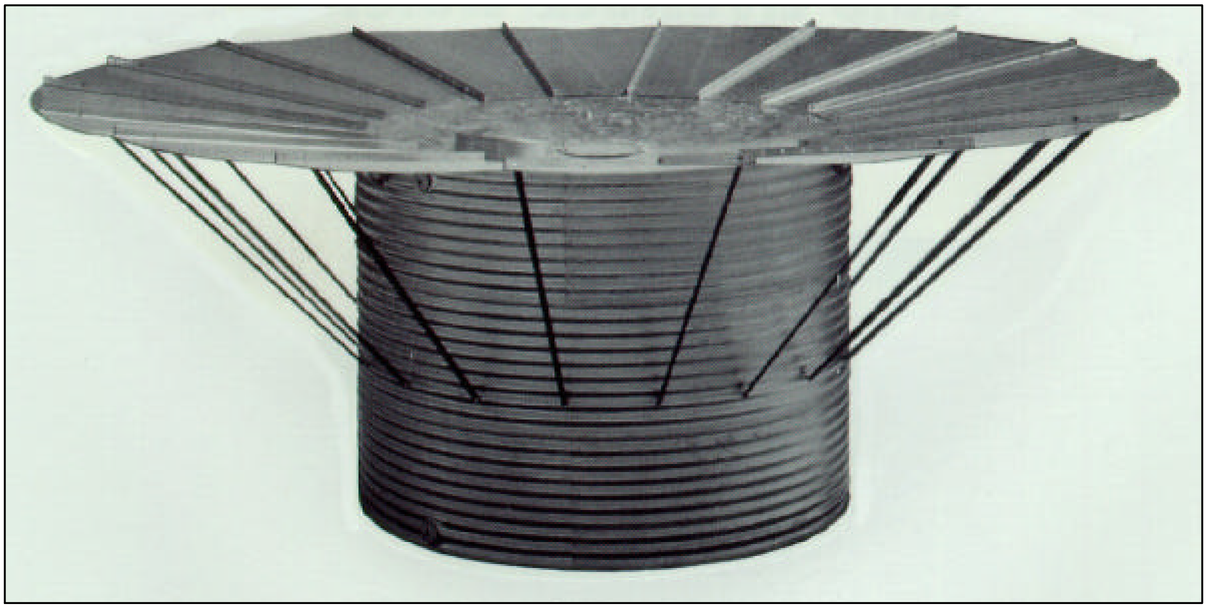

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Figure 6.5.1
Photograph of Inverted Umbrella Tank
and Drinking Trough
Col-Tex Restoration
Colorado City, Texas

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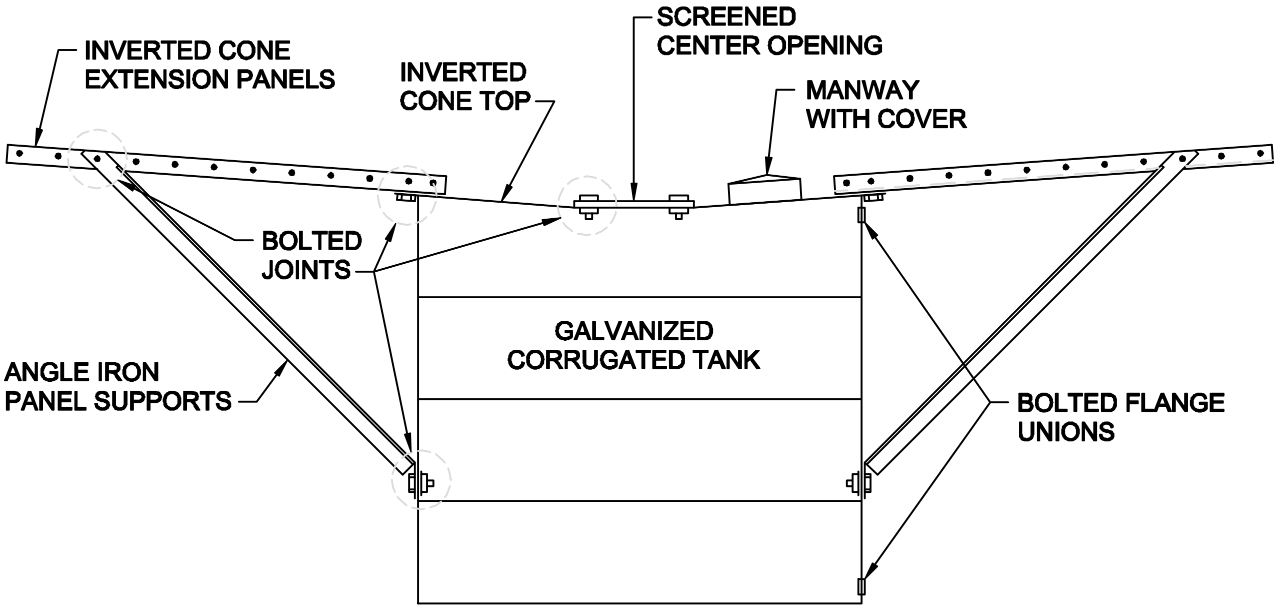
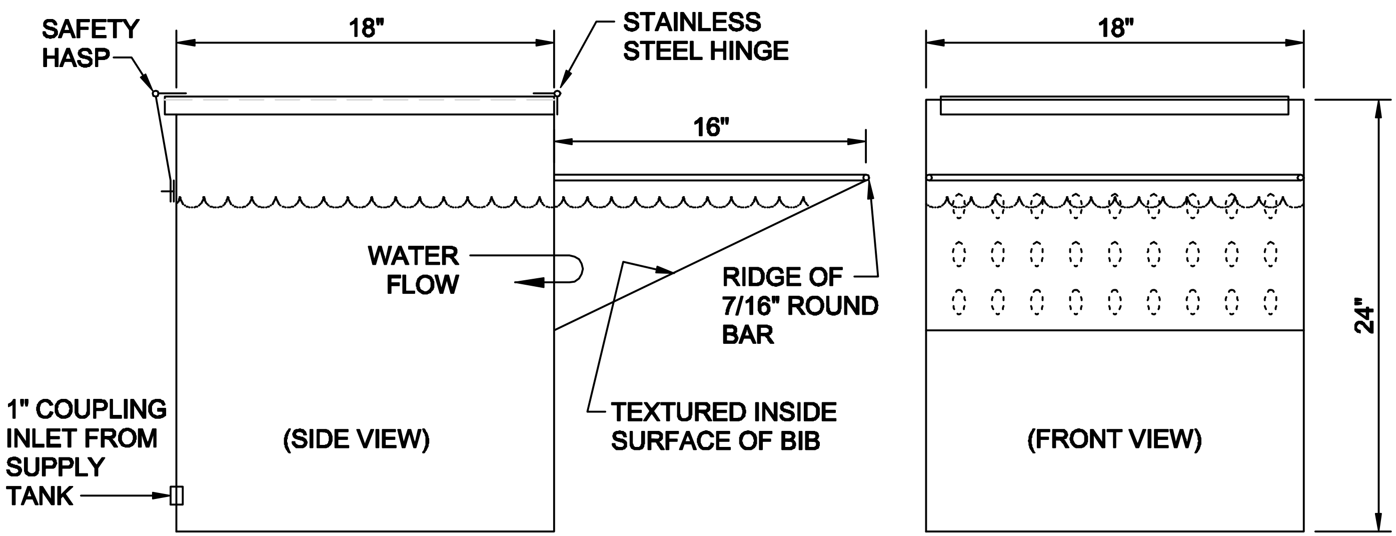


INVERTED UMBRELLA TANK

(2,350 GALLONS)



DRINKING TROUGH

E N T R I X

Figure 6.5.2
Wildlife Water Catchment and Drinking Trough Design
Habitat Restoration
Colorado City, Texas

PROJ. NO: 128816	CK:	DATE: 01/00

determined, a general suggestion for upper limits of total dissolved solids (TDS) is 5,000 mg/l. There are no specific water quality limits for ungulates (deer) (Payne and Bryant, 1998). The quality of water in the Colorado River is frequently above the suggested threshold. Average TDS for the period of record (1967 to 1982) is 7,335 mg/l (USGS, 1999). Small mammals and upland wildlife will benefit from a better quality water source in the restoration project area.

The guzzler will be placed at the eastern end of the restoration project area within the upland restoration area (Figure 6.5.3). The planting plan for this upland area will be designed to provide variability in food sources and adequate areas of cover adjacent to the guzzler for target species.

6.5.3 Timing of Activities

The construction of the water catchment system will commence in the second year of restoration activities. Following site preparation and fabrication of the tank and trough, the guzzler will be installed in the second quarter of the second year.

6.6 Provide Public Use Area

The goal as stated in Section 6.0 is to provide a limited-access public use and interpretive area for environmental education. Objectives relating to this goal are:

- Construct an interpretive trail on the south side of the Colorado River;
- Provide interpretive signs along the trail to educate the public;
- Limit access to the wildlife area through a locked gate to be opened upon reservation; and
- Provide a scenic overlook of the project area.

6.6.1 Background

The citizens of Colorado City and Mitchell County are interested in developing areas along the Colorado River and its nearby tributaries for public use and recreation. At this time, there is a walking trail located along the banks of Lone Wolf Creek from Ruddick City Park to the business district area at 2nd Street. This trail is used for recreational purposes and does not offer interpretive signs or direct educational information for the general public. Access to the area is open.

The public use area proposed within the project site will complement the recreational trail along Lone Wolf Creek, by providing an interpretive trail in the area of the Colorado River. Interpretive signs that include information about plant and animal identification, regional geology, river systems and native habitats will

N

200 0 200 Feet

Legend

Guzzler Location

Tree & Shrub Transplant Areas

ENTRIX

Figure 6.5.3

Location of Wildlife Water Catchment
Col-Tex Restoration
Colorado City, Texas

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be located along the trail. Knowledge gained through use of the interpretive trail may be applied to riparian and upland habitats throughout the region.

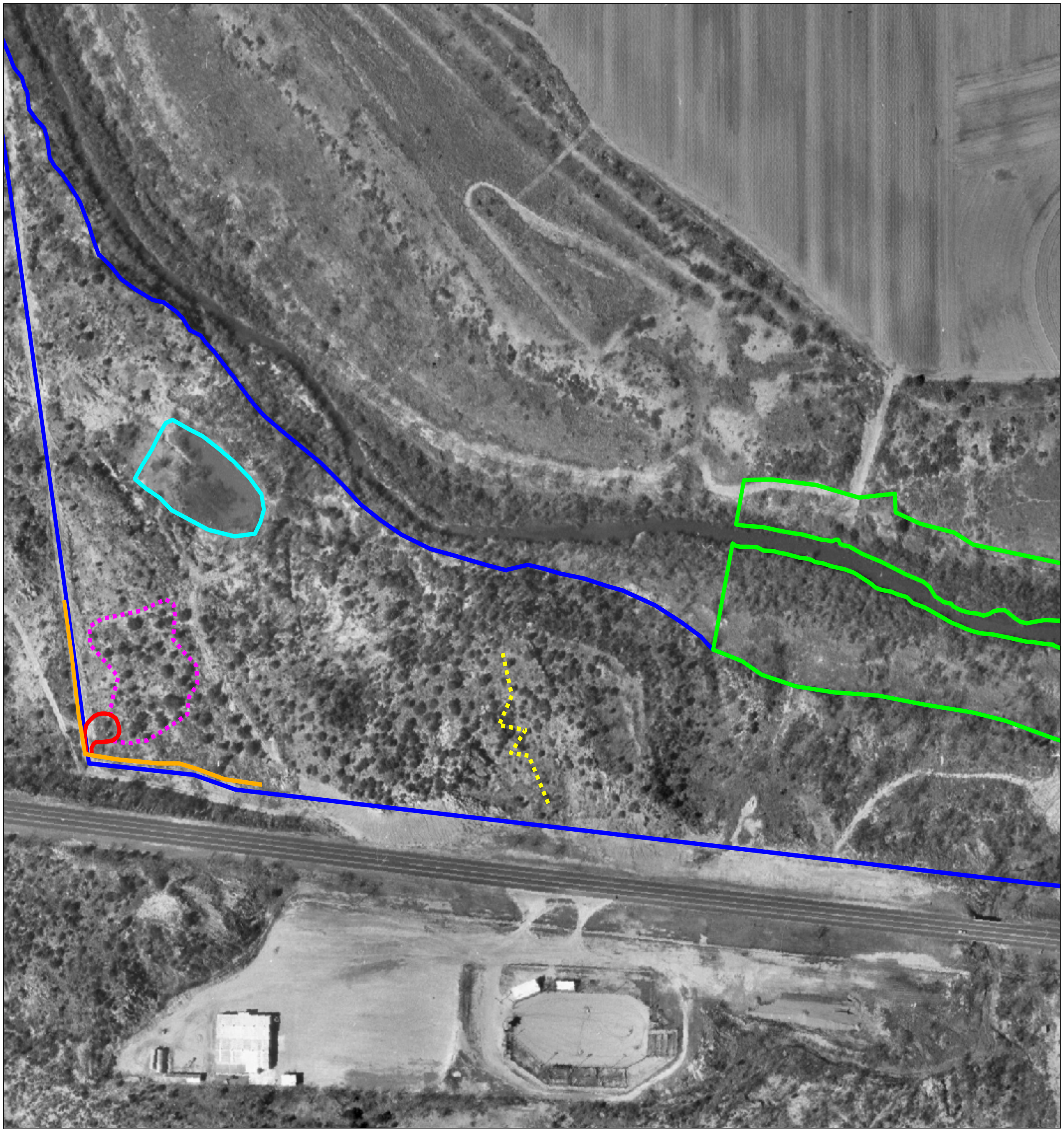
6.6.2 Planned Action

At the PRP's option and with TDCJ approval, an interpretive trail and a scenic viewing area with signs is proposed on the south side of the Colorado River within the upland area. The interpretive trail will originate at a parking area located at the southwestern corner of the property and will be accessible from Highway 80 (Business I-20). This parking area will accommodate buses to park and turn around. The interpretive trail will be a loop trail approximately 0.5 miles long and will follow a gentle gradient offering a view of the pond, upland habitat and riparian vegetation (Figure 6.6.1). Interpretive signs will be located along the trail. Access to the parking area and trail will be through a locked gate. Tour groups will need to coordinate entry with TDCJ representatives. The controlled public access will be scheduled to minimize negative impacts to the conservation area and the wildlife utilizing the various habitats.

The scenic overlook area will be constructed on the bluff that is located just east of the pond area. Access to the overlook will be by a trail/stairway, as shown on Figure 6.6.1. A limited parking area will be developed at the base of the hill where the trail begins. Access to the overlook will be open to the general public. A security fence will be constructed to limit access to the remainder of the wildlife habitat area.

6.6.3 Timing of Activities

The construction of the public use area will commence during the second year of restoration activities. It is anticipated that the trails will be completed during the second year.



Legend

- Interpretive Trail
- Scenic Overlook Trail
- U-Drive with Locked Gate
- Chain Link Fencing

Restoration Elements

- Riparian Restoration
- Uplands Enhancement and Conservation
- Pond Enhancement

N

100 0 100 Feet

E N T R I X

Figure 6.6.1

Public Use Area
Col-Tex Restoration
Colorado City, Texas

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6.7 Summary of Project Schedule

The habitat enhancement and restoration plan will be implemented starting in the fall of the first year following the execution of the settlement agreement and continue during the next two years. It is anticipated that construction of all habitat elements will be completed in the spring of the third year. The Monitoring Plan, as described in the next section will begin after construction of each restoration plan element is complete. For the riparian area, monitoring will be begin for each phase independently. Table 6.7.1 summarizes the proposed timing of the restoration activities.

Table 6.7.1 – Summary of Proposed Timing of Activities

	Erosion Control	**Riparian**	**Upland**	**Pond**	**Guzzler**	**Public Use**
1st Year						
3rd Qtr		• Site Preparation	• Site Preparation			
4th Qtr	• Installation • P.E. Certification	• Site Preparation	• Site Preparation	• Installation • P.E. Certification		
2nd Year						
1st Qtr		• Phase I – Transplant Cuttings, Seed Grasses and Plant Seedlings	• Seed Grasses and Plant Seedlings	• Planting • Planting Certification	• Fabrication	
2nd Qtr					• Site Preparation • Installation • Certification	• Installation • Certification
3rd Qtr		• 1st Monitoring Event (Phase I)	• 1st Monitoring Event	• Evaluation of Emergent Vegetation		
3rd Year						
1st Qtr		• Phase II – Plant Seedlings				
3rd Qtr		• 2nd Monitoring Event (Phase I & II)	• 2nd Monitoring Event	• Evaluation of Emergent Vegetation • Vegetation Certification		

Table 6.7.1, continued – Summary of Proposed Timing of Activities

	Erosion Control	Riparian	Upland	Pond	Guzzler	Public Use
4th Year						
3rd Qtr		• 3rd Monitoring Event (Phase I & II)	• 3rd Monitoring Event	• Evaluation of Emergent Vegetation, as needed • Vegetation Certification, if not previously met		
5th Year						
3rd Qtr		• 4th Monitoring Event (Phase I & II)	• 4th Monitoring Event			
6th Year						
3rd Qtr		• 5th Monitoring Event (Phase I & II) • Certification of Phase I*	• 5th Monitoring Event • Certification*			
7th Year						
3rd Qtr		• 6th Monitoring Event (Phase II) • Certification of Phase II*				

* Assuming a curative response was not performed.

7.0 MONITORING PLAN

Monitoring of enhancement sites is a critical part of the restoration process. The purpose of monitoring is to:

- obtain an objective assessment of project progress towards pre-determined project goals and performance standards;
- identify and correct problems through an adaptive management approach; and
- ensure that the PRP meets its compensatory restoration obligations.

Monitoring of the site will be a cooperative process. The PRP is responsible for implementing the monitoring plan. The Trustees will oversee monitoring efforts, review monitoring results and make decisions regarding corrective actions. Monitoring of the site will utilize qualitative methods; however, in the event that there is disagreement as to whether the performance criteria are being met by a particular portion of the restoration project or the project as a whole, a quantitative survey would be conducted. Each project component will undergo certification by the Trustees at the time of installation if installed to design specifications. The erosion control structure, pond structure, pond planting, wildlife water catchment, and public use area will not be monitored following installation. Certification of the pond and erosion control structures will require verification by a licensed Professional Engineer (PE). Final certification of the riparian habitat restoration and upland habitat enhancement will occur upon completion of their respective monitoring period if performance standards are met. Final certification of the emergent vegetation along the perimeter of the pond will occur upon performance standards being met or following an attempt to supplement emergent vegetation, if supplementation is needed and is performed according to design specifications.

7.1 Performance Standards

Performance standards are criteria used to objectively evaluate the progress of restoration projects in achieving pre-determined objectives and to determine whether corrective actions need to be implemented. Because habitat functions are difficult to measure directly, performance standards are based on an assessment of the structural attributes of restored habitats. In this way, structural attributes serve as surrogate measures of habitat function. Once site conditions have met or surpassed the pre-determined structural thresholds, it is assumed that the desired functions are either currently being provided or will be provided given time.

Performance standards have been established for the elements of the restoration plan that are to be monitored (i.e. riparian restoration, upland enhancement, and emergent pond vegetation). Performance standards corresponding to plant survival have been established for the riparian and upland components of the restoration project. Parameters to measure development of the emergent vegetation associated with the pond enhancement correspond to area of cover.

In the riparian and upland restoration sites both planted seedlings, as well as plants that naturally colonize the planting areas (desirable species only), will be counted towards achieving the performance standards. Survival will be determined based on the presence of living vegetation (i.e., leaves, buds, flowers, etc.) and will be assessed after leaf-out in the spring and prior to leaf-drop in the fall. For purposes of assessing these performance standards, multiple stems sprouting from the root stock of a single tree or shrub seedling will be considered to be a single stem, and stem density per acre will be expressed as the average for the total acreage planted.

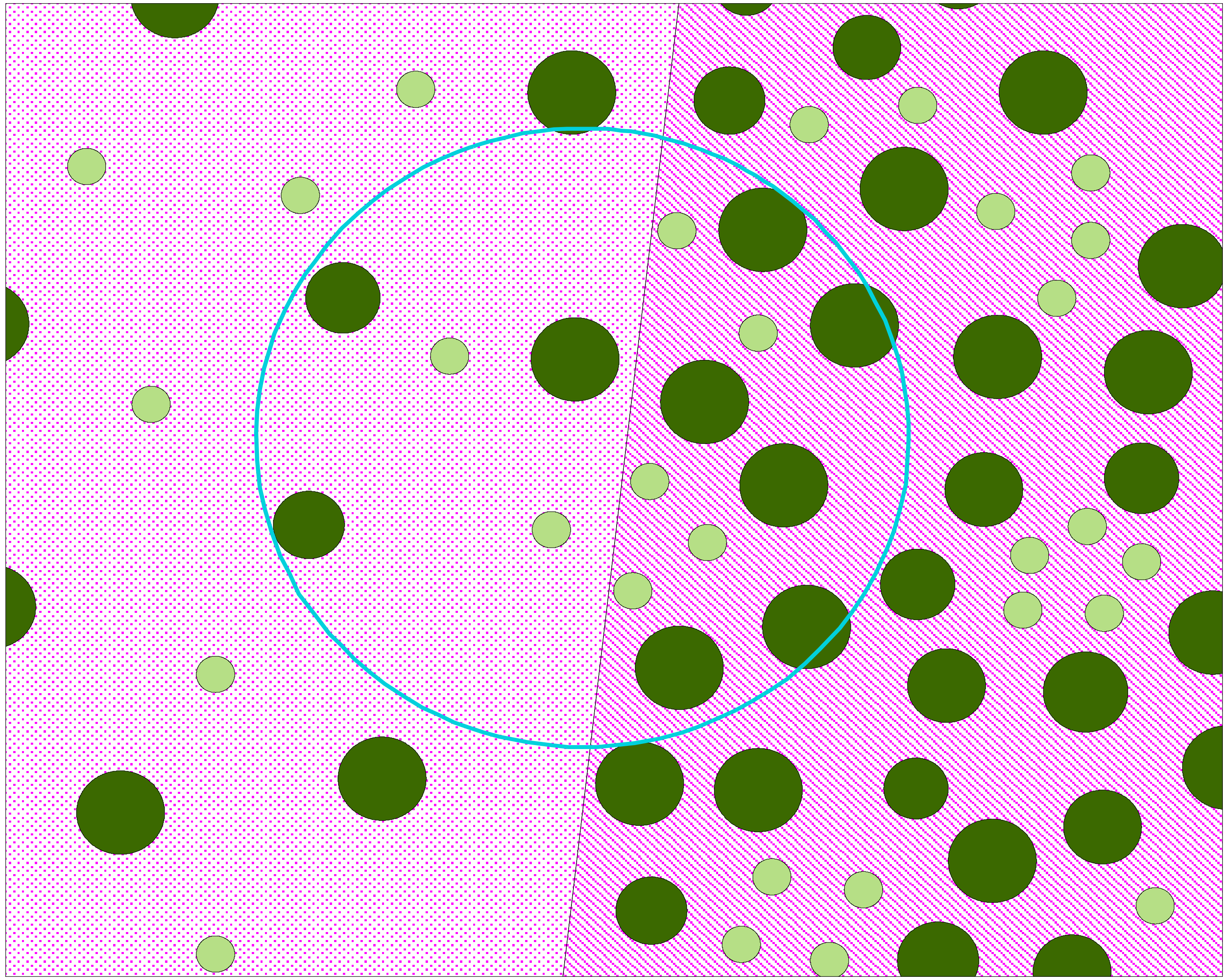
7.1.1 Riparian Habitat Restoration

Performance standards for the riparian enhancement project are based on the stem density of woody plants growing within the planting areas. Accordingly, dense planting areas will have a higher stem density requirement than areas with sparser plantings. In addition, within each planting zone the performance standards will be based upon tree to shrub ratios. Table 7.1.1 shows the targets developed to evaluate the riparian enhancement areas:

Table 7.1.1 – Performance Criteria for Riparian Restoration

Planting Zone	Dense Planting Areas		Sparse Planting Areas		Weighted Average	
	Trees/ac	Shrubs/ac	Trees/ac	Shrubs/ac	Trees/ac	Shrubs/ac
2	202	23	54	6	122	14
3	135	90	36	24	85	56
4	113	112	30	30	90	89

Within each planting zone, the specific performance criteria will be taken as a weighted-average of both the dense and sparse targets. Figure 7.1.1 illustrates the use of weighted-averages within zones of the riparian restoration. The corresponding performance criteria shown in Table 7.1.1 must be achieved by the last year of monitoring.



1) A circular plot will be randomly selected using the Quantitative Sample Location Selection method described in Section 7.3.1

2) Once the plot has been selected, the acreage of sparse and dense planting areas will be determined.

In this example, there is 0.06 acres of sparse planting area and 0.04 acres of dense planting area.

3) Then, based upon the relative acreage of sparse and dense planting areas, a weighted average for the tree and shrub targets will be calculated based upon the planting zone.

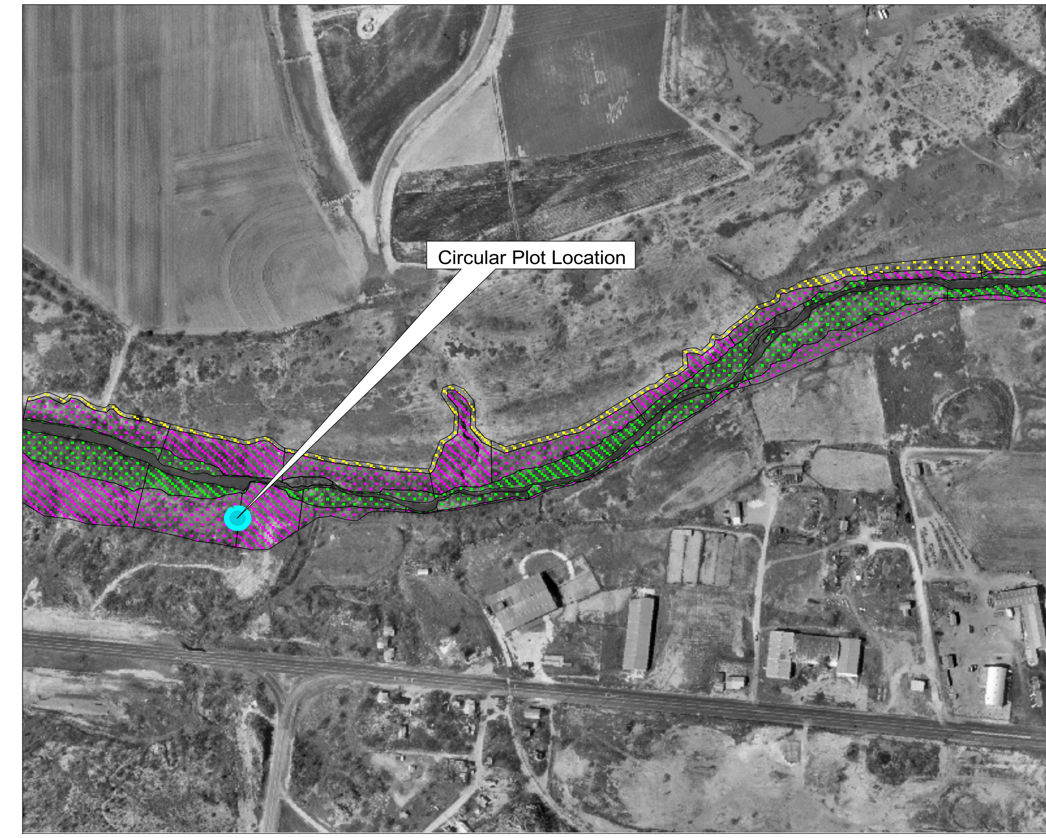
In this example, the plot area is located in zone 3 and the following weighted averages were obtained:

Trees = (0.06 dense acre X 36 trees/acre) +
(0.04 dense acres X 135 trees/acre)
= 7.6

Shrubs = (0.06 sparse acres X 24 shrubs/acre) +
(0.04 dense acres X 90 shrubs/acre)
= 5.0

4) Finally, all transplants and volunteer woody species within the plot area will be recorded by tree and shrub species to determine if the calculated target has been achieved

In this example, there are 9 tree and 7 shrub species located within the plot area. Therefore, in this example, performance criteria have been met.



Legend

Circular Plot Area

Tree

Shrub

Zone

3 Dense

3 Sparse

ENTRIX

Figure 7.1.1

Use of Weighted Averages
within Zones of the Riparian Restoration
Col-Tex Restoration
Colorado City, Texas

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7.1.2 Upland Habitat Restoration

Transplant Survival. Performance standards for transplant survival are based on the stem density of woody plants growing within the planting areas. A minimum density of 250 living trees and shrubs per acre (planted and desirable volunteer species, including mesquite) must be achieved by the last year of monitoring.

Total Plant Density. Performance standards for the seeded herbaceous strata are based on the Conservation Reserve Program (CRP) land specifications used in Mitchell County, Texas. Based on this specification, a minimum of ½ plant per square foot must be achieved by the last year of monitoring.

7.1.3 Emergent Pond Vegetation

Area of Cover. Performance standards for the emergent vegetation along the perimeter of the pond are based on area of cover. A minimum of 0.1 acres of emergent vegetation must be achieved by the third quarter monitoring event of the third or fourth year, depending on the pond reaching adequate water levels. If performance standards are not met at this time, efforts to assist development of emergent wetland vegetation will be necessary.

7.2 Qualitative Monitoring

Monitoring methods are the techniques used to measure actual project performance relative to the stated performance standards. Field data will be compared to performance standards to determine if the project has met or exceeded pre-determined criteria, and in the case of annual surveys, is likely to meet those criteria by the end of the monitoring period.

The Trustees in conjunction with the PRP will utilize pedestrian surveys, photographic logs and potentially aerial photographs to determine if performance standards are being met for the riparian, upland, and emergent pond vegetation portions of the project and provide direction regarding corrective actions.

Photographs for each element of the restoration plan will be taken from permanently marked locations to provide visual documentation of changes over time. Date, time, weather conditions, and photographic equipment used should be noted for each photograph taken. To the extent possible and practicable, equipment and time of day that a site is photographed should remain constant. Such constancy provides continuity in the record, making it easier to interpret and draw conclusions.

Pedestrian surveys will be performed for the riparian, upland, and emergent pond vegetation elements of the restoration to qualitatively assess the success of that element in reaching its pre-determined goals and performance standards. For this purpose, permanently marked viewing points will be chosen that will provide an unbiased and comprehensive evaluation of the particular restoration element. Annual pedestrian surveys will be performed at the same permanently marked viewing points or along the same transects.

Aerial Photographs of the entire restoration site will be taken at a minimum: prior to project implementation to document pre-existing site conditions, following project implementation, and after project certification.

7.2.1 Riparian Habitat Restoration

The goal for the monitoring program of the riparian restoration is to determine the survival rate of the planted materials, determine the relative health of the community including both natural and planted materials, and determine the relative rate of growth of the plants. Monitoring of the riparian enhancement project will involve assessing key aspects of the project through time.

Photographic records. Photo monitoring will consist of photographing key project areas/features from fixed photo-points (i.e., same station, same angle) to provide a consistent basis for visually comparing vegetation growth and development through time. The exact number and location of photo-monitoring stations will be determined in the field during project implementation.

Pedestrian Surveys. Inspections will include pedestrian surveys of the riparian enhancement areas. Relevant information such as general site conditions, damage by herbivory or vandalism, erosion, wildlife utilization, etc. will be documented on monitoring data sheets.

7.2.2 Upland Habitat Restoration

The goal for the monitoring program of the upland restoration is to evaluate germination and development during the establishment period and provide an assessment of revegetation restoration success.

The anticipated timeframe for establishment is one to three full growing seasons after seeding. Vegetation stand establishment and development will be observed annually beginning in the later part of the first full growing season following seeding. Any deficient areas will be noted and mapped.

Several growing seasons may be necessary before all the species in a seed mixture establish. Many xeric plant species will not germinate until specific climatic or environmental conditions occur. Seed can remain dormant and viable for such species for many years. Therefore, the time period for evaluating the initial germination and establishment success of restoration revegetation efforts will be based on both observed establishment and the climatic conditions. This approach will avoid needless work and minimize the application of excessive amounts of seed that can adversely affect development and diversity of the desired upland vegetation community.

<u>Photographic records</u>. Photo monitoring will consist of photographing key project areas/features from fixed photo-points (i.e., same station, same angle) to provide a consistent basis for visually comparing vegetation growth and development through time. The exact number and location of photo-monitoring stations will be determined in the field during project implementation.

<u>Pedestrian Surveys</u>. Inspections will include pedestrian surveys of the riparian enhancement areas. Relevant information such as general site conditions, damage by herbivory or vandalism, erosion, wildlife utilization, etc. will be documented on monitoring data sheets.

7.2.3 Emergent Pond Vegetation

The goal for the evaluation program of the emergent pond vegetation is to determine if emergent vegetation can establish along the perimeter of the pond by natural colonization or if efforts to assist development of emergent wetland vegetation may be necessary.

Evaluation of the emergent pond vegetation will entail visually assessing and documenting development of vegetation within the areas along the perimeter of the pond that provide suitable subtrate for emergent vegetation establishment. Monitoring will include: 1) determining area of cover of emergent vegetation, 2) documenting overall site conditions through same station, same angle photo-monitoring, and 3) compiling a species inventory. These monitoring tasks will be performed by pedestrian survey of the project area.

7.3 Quantitative Monitoring

The quantitative survey would include a detailed analysis of the phase of the project in question. If quantitative monitoring is required, results from the quantitative survey and level of services provided will be agreed upon between the parties before the certification of the projects completion. Quantitative monitoring methods that correspond to the established performance standards have been developed for the riparian and upland components of the restoration project.

Quantitative monitoring will consist of non-destructive vegetation sampling to collect data about the development of herbaceous and woody vegetation colonizing the planting areas, including both planted and naturally recruited trees, shrubs, and grasses. Monitoring will include measurements of total cover, woody plant density, and transplant survival and growth within restoration areas. Appropriate sampling methods will be used to monitor vegetation community development, and transplant establishment and growth. Monitoring will be performed to obtain unbiased samples from the restored areas where they are taken. The following quantitative monitoring methods will be used for the riparian and upland portions of the restoration, if necessary.

7.3.1 Monitoring Methods

Transplant Survival (Riparian and Upland). Circular plots will be used to establish woody stem density on a per acre basis. The circular nature of the sampling plot avoids bias in samples that may be introduced by the linear nature of transplant arrangements and the linear orientation of belt transects. Sample locations will be selected randomly from an evenly distributed grid as described below. Plot radius for monitoring of upland areas vegetated in herbaceous species is set at 16.7 feet, which equals $1/50^{th}$ of an acre. For riparian areas and upland areas dominated by trees the plot radius would be set at 37.2 feet, which equals $1/10^{th}$ of an acre.

All transplants and volunteer woody species rooted within the plot area will be recorded by species. In addition, each transplant will be monitored for establishment and growth. The number of living transplants and their height and stem diameter at the root crown will be recorded for each transplant species series. Height will be measured from root crown to apex of the main tree stem or longest branch in the case of shrubs or succulents.

Quantitative Sample Location Selection. A custom grid will be used to locate sampling points within the area to be monitored. Using a custom-spaced grid ensures that the transects are distributed evenly across the area to be sampled and that the entire area is adequately represented in the sample population. Custom grids will be established by defining the boundaries of each type of area (i.e., strata) to be monitored. Grids will be developed to insure that a total of 50 sample points fall within the area to be sampled.

Each grid point falling within the target vegetation community to be sampled represents a potential sampling location. Each point within the grid will be randomly assigned a grid point number from 1 through 50. When monitoring is conducted, grid points will be sampled in numeric order until statistical adequacy for the field population sample is reached or exceeded. A minimum sample size of 15 and a maximum sample size of 50 will be set for each vegetation unit monitored. Grid locations will be identified in the field by GPS or by pacing from known landmarks.

Sample Population Adequacy. Sample mean and standard deviation will be determined for each area sampled. Adequacy of sample populations will be determined in accordance with the standard formula for calculating sample size:

$$N_{min}=(t^2s^2)/(dx)^2$$

Where:
N = number of samples collected,
t = the two-tailed distribution value for 80% confidence with N-1 degrees of freedom,
s = variance of the estimate calculated from the initial samples,
d = Precision (0.2 for 80 C.I.), and
x = the mean of the estimate calculated from the initial samples.

Sample populations will meet or exceed minimum size requirements for revegetation success sampling. A minimum of 15 samples and a maximum 50 samples will be taken within each strata.

Total Plant Density (Upland Only). Similar quantitative methods to those described above in the transplant survival section will be utilized to establish plant stem density on a per acre basis. The method will differ only with respect to the plants surveyed. Total plant density will be measured by recording all desirable species, which includes herbaceous, shrub, and tree (including mesquite) species.

7.4 Corrective Actions

7.4.1 Maintenance Activities

Maintenance activities are corrective actions undertaken after initial implementation in order to meet pre-determined performance standards. While it is understood that the initial planting density is greater than the required performance standards, the Companies will make efforts to ensure survival of the plantings. These maintenance activities may include modifications to watering schedules, mulching, fertilizing, pest control, etc. If needed, the Trustees can request maintenance activities to be done under two circumstances. First, the trees or shrubs within a planting area fail to grow over two consecutive growing seasons, as determined by qualitative assessments. If no growth occurs in the last year of monitoring, but growth has been demonstrated up to that point, then no additional monitoring or maintenance activities are required. Second, a bare patch exists within a planting area that is larger than the pre-determined threshold value. This threshold value corresponds to 1/8 of an acre on the riparian restoration area and ¼ of an acre on the upland restoration site.

7.4.2 Curative Responses

A curative response is a corrective action that is triggered when 15% replanting in a riparian zone or 25% replanting in the upland area is required based upon annual monitoring results. For any zone (riparian) or area (upland) of this project, a maximum of two curative responses will be performed. Reinforcement plantings are designed to replace some or all of the plants lost to mortality. Stocking rates for reinforcement plantings will be determined based on the performance standards and applicable survival data. Enough additional vegetation will be planted or seeded to ensure that the performance standards will likely be achieved after allowing for expected seedling mortality. The stocking rate for reinforcement plantings is not expected to exceed the initial stocking rate. If reinforcement planting is needed, the original species composition may be altered to favor those species exhibiting the highest survival rates based on monitoring data.

7.5 Timing and Duration of Monitoring

Due to the phased nature of the installation, a phased approach to monitoring and certification of the restoration site will be taken. The riparian and upland components of the restoration will be monitored for a period of five (5) consecutive years following installation. This means that project components installed in the first year will commence their monitoring period upon installation and will be certified if performance standards are met at the end of the five-year period. Project components installed in the second year will in turn begin a five-year monitoring period once installed and will obtain certification if performance standards are met at the end of that monitoring period.

7.5.1 Riparian Restoration

Monitoring will take place annually, at the end of the growing season prior to leaf drop, with the exception of as-built surveys. As-built surveys will be performed within 60 days of implementing major project components (i.e., salt cedar removal, site preparation, planting, etc.). If necessary, additional as-built surveys will be conducted within 60 days after any reinforcement plantings. As-built surveys for reinforcement plantings will document the quantity and species of trees and/or shrubs used for mortality replacement.

Photo-monitoring will be conducted 1) prior to project implementation to document pre-existing site conditions, 2) at the time of the as-built survey, following project implementation, and 3) at the annual end-of-growing season monitoring. Monitoring for tree and shrub plantings will commence at the end of the growing season following the initial planting phase and will be conducted annually. If a curative response is required, the monitoring period will be extended by a maximum of two growing seasons.

7.5.2 Upland Restoration

Monitoring will take place annually, at the end of the growing season with the exception of as-built surveys. As-built surveys will be performed within 60 days of implementing major project components (i.e., site preparation, planting, etc.). If necessary, additional as-built surveys will be conducted within 60 days after any reinforcement plantings. As-built surveys for reinforcement plantings will document the quantity and species of trees or shrubs used for mortality replacement. Photo monitoring will be conducted prior to project implementation to document pre-existing site conditions, following project implementation at the time of the as-built survey, and at the annual end-of-growing season monitoring.

Monitoring will commence at the end of the growing season following the initial planting phase and will be conducted annually. If a curative response is required, the monitoring period will be extended by a maximum of two growing seasons.

7.5.3 Emergent Pond Vegetation

The schedule for evaluating and certifying the emergent vegetation is as follows: natural colonization will be evaluated after water levels in the pond have stabilized and a complete growing season has ended. As scheduled, this would occur during the 3rd Quarter of the third year and the fourth year of restoration activities. If the established performance criteria have not been met by the 3rd Quarter of the fourth year, the emergent vegetation would be supplemented during the 1st Quarter of the fifth year by seeding or transplants. If augmenting is required, the emergent vegetation will be certified in the 1st Quarter of the fifth year when supplemental planting is performed according to design specifications. No additional attempts at supplementing the emergent vegetation will be required following the augmentation attempt. If performance criteria for the emergent vegetation are met during earlier annual monitoring events (3^{rd} Quarter of first, second, or third years), the emergent vegetation will be certified at that time, and supplemental efforts will not be required.

7.6 Monitoring Reports

Monitoring reports will be prepared and submitted to the Trustees each year during the five-year monitoring period. Monitoring reports will contain the results of all annual monitoring events (data and photographs) and all annual results will be presented in cumulative fashion. Monitoring reports will be submitted to the Trustees no later than December 31st of the year during which the monitoring event was conducted.

Monitoring reports will be submitted for each major milestone of the restoration project. The first report will be submitted after initial restoration work has been completed on all aspects of the project (i.e., upland, riparian, and erosion and sediment control). This report will document and detail the restoration effort. Any variances from the work plan or standard practices described in the restoration plan will be noted in this document. A summary of work activities and their respective start and completion dates will be included.

Monitoring reports will consist of introduction, methods, results, and discussion sections. The introduction will include a brief narrative description of existing conditions, a site location map, maps showing key sampling locations (i.e., transects, photo-stations, etc.), and a review of performance standards. The methods section of the report will detail the methodology used to assess project performance for each of the enhancements. Results from monitoring tree and shrub plantings will be summarized in the results section in tables and/or as text. Monitoring data sheets will be included as an appendix. The Results section will also include one set of labeled photographs taken at each of the fixed-point photo-monitoring stations. No formal wildlife surveys will be conducted, but sightings of wildlife and/or indirect evidence (scat, tracks, etc.) of wildlife use of the site will be documented on the monitoring forms. With regard to monitoring of the pond enhancement, monitoring data for both hydrology and precipitation will be presented in monitoring reports in both tabular and graph format. Since the post-construction topography of the ponds will be known, the areal extent of ponding (i.e., water surface area) can be determined from the water surface elevation data. Water surface elevation data will be collected on a monthly basis using a staff gage and included in the annual monitoring reports.

The discussion section will include an assessment of project performance based on the monitoring results directly related to set performance standards, and indirectly by noted use of the site by wildlife. The need for any corrective actions (i.e., reinforcement planting) will also be identified in this section. If necessary, a proposed schedule for implementing corrective actions will be included. The discussion section will also include a description of any problems observed within the project site including, but not limited to, excessive inundation, drought, invasion by undesirable plant species, herbivory damage, plant diseases, excessive erosion, and evidence of vandalism or inadvertent damage.

A final monitoring report will be submitted following certification of all project components. This report will include data and a description of the final monitoring evaluation. It will also provide a summary and analyses of annual monitoring results for the monitoring period for the entire site.

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